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SITE C CLEAN ENERGY PROJECT

EIS Technical Appendix: Heritage Resource Assessment Report Volume 4 Appendix C

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REPORT

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Executive Summary

Palaeontological, archaeological, and historical sites, objects, and features are the key indicators that comprise the heritage resources VC for the Site C Clean Energy Project. This Appendix describes the methods and results of a three year program to identify heritage resources in the LAA. The program was conducted by a team of consultants, led by Golder Associates Ltd. and including AMEC Environment & Infrastructure, Millennia Research Ltd., Branta Biostratigraphy Ltd., and Donald Luxton & Associates, Inc. A summary of the results is provided as follows.

Palaeontological Resources

A review of existing information focused on the preparation of a palaeontological resources overview assessment to create a geologically-based palaeontological sensitivity map for the dam and generating station and reservoir. The overview was subsequently expanded to include the remaining Project components. The overviews included a detailed literature review, review of orthophotos, and communication with key scientific and regulatory personnel.

The review of existing information identified 899 potentially fossiliferous bedrock and sediment exposures within the LAA as palaeontological sensitivity areas. Of these 899 locations, 41 contained documented palaeontological resources and were regarded as having the highest level of sensitivity ("extreme"). The remaining palaeontological sensitivity areas were ranked ("high", "medium", and "moderate") according to their likelihood of containing unique or *in situ* fossils. Areas with "low" palaeontological sensitivity were not identified. During subsequent field work, some of the palaeontological sensitivity area rankings were revised as a result of field observations, which created a "negligible" sensitivity category for locations that did not have potential to contain fossils.

In 2011 and 2012, palaeontological field work included surface inspection to ground-truth palaeontological sensitivity areas identified during background research, which resulted in revisions and additions to the original palaeontological sensitivity model. Field work involved pedestrian, helicopter, truck, and boat-based survey to confirm fossil presence or absence, and abundance at 609 identified palaeontological sensitivity areas, 287 of which were visited on foot. A sample of fossil specimens was acquired from 104 palaeontological sensitivity areas within the LAA from 190 individual waypoint locations. The assemblage includes 285 fossil specimens representing a variety of taxa. Palaeontological analysis followed standard industry practice for the identification and description of fossils, drawing upon reference collections, published scientific articles, and external expertise, as required. Further analysis and discussion with scientific experts will be undertaken to assist with refined species identification. Fossil specimen collection adhered to guidelines proposed in the *Fossil Management Framework Consultation Summary Report*.

Post-field analysis resulted in some positive palaeontological sensitivity areas being merged together in recognition of their observed fossil content, proximity, and similarity. Following this analysis, 173 positive palaeontological sensitivity areas have been documented within the LAA, and an additional 11 beyond the LAA. The significance assessment identified 26 Class I, 113 Class II, and 34 Class III palaeontological sensitivity

areas. Class I palaeontological sensitivity areas are considered the most important locations and may contain unique fossils *in situ*, abundant and diverse specimens, good specimen preservation, have multiple time depths represented, have potential educational opportunities, or commercial opportunities. Class II palaeontological sensitivity areas are considered moderately important and may contain commonly known fossils *in situ*, moderate preservation, moderate abundance, and sometimes coincide with areas where amateur fossil collection has taken place. Class III positive palaeontological sensitivity areas are those locations that have low specimen abundance, poor preservation, and common specimens in *ex situ* context. The significance determinations and resulting site classes (or classifications) are linked to potential mitigation measures.

Palaeontological work has addressed the requirements of the *Canadian Environmental Assessment Act* 2012, in that palaeontological resources were assessed in relation to the mandates, objectives, and intents of existing legislation and policies at the federal, provincial, and municipal levels of government. In the absence of specific federal guidelines for the protection of palaeontological resources, assessment of palaeontological resources required by the CEA Agency generally need to meet the requirements of existing provincial legislation. Given the lack of provincial legislation to protect palaeontological resources, the palaeontological resource assessment embraced the spirit of the *British Columbia Fossil Management Framework* and employed internationally recognized best practice for palaeontological resource assessment.

Archaeological Resources

Previous archaeological research within the LAA principally involved a multi-year inventory study conducted by archaeologists from Simon Fraser University. The research identified and recorded over 300 archaeological and historical heritage sites in an area that includes and extends beyond the heritage resources LAA. Of these, systematic excavations took place at two prehistoric sites, evaluative testing was done at nine sites, and systematic surface collections were conducted at eight sites. Work also took place at Rocky Mountain Fort and Rocky Mountain Portage House.

In the interval between the end of the 1970s and 1980s research for the previous Site C hydro-electric project and the onset of work for the present Project, a number of office- and field-based studies were carried out for BC Hydro, either for the Site C Project or to address other kinds of regulatory requirements.

Following discussions between BC Hydro and the BC Archaeology Branch, a predictive model of archaeological resource potential for the Project was developed by Millennia Research and later expanded to include portions of the LAA outside of the dam site and reservoir.

In 2010 field work focused on testing the archaeological predictive model. In 2011 and 2012, field inventory was undertaken within lands modeled as having high, moderate, and low archaeological site potential throughout the LAA, with most effort focused on high potential areas. Field inspections included systematic visual surface inspection and over 50,000 subsurface tests, consisting of a combination of systematic, adaptive, and judgemental shovel tests, auger or backhoe tests in locations with the potential for deeply buried archaeological deposits, and evaluative tests within select archaeological sites.

Specific archaeological methods were also designed to test for archaeological sites in the following contexts:

- Well-defined, terrestrial margins of wetlands
- The saturated side of wetland margins
- Small (≤100 m²), well-defined landforms
- Lands peripheral to the historic fur-trade post of Rocky Mountain Fort

Archaeological analyses included standard quantitative and descriptive analyses of artifacts, radiocarbon dating, and x-ray fluorescence analysis to identify the geological sources of obsidian artifacts. Data from these analyses were used to assist in evaluating the heritage significance of individual archaeological sites, using the heritage significance criteria outlined in Appendix D of the *British Columbia Archaeological Impact Assessment Guidelines*. To assess the potential effects of erosion on archaeological sites, the E-PAST tool was developed and applied to archaeological sites located within and adjacent to the reservoir.

Prior to the assessment, 111 archaeological sites had been recorded in the LAA, including previously recorded sites on lands that could not be accessed during the field inventory. During the assessment, 140 additional archaeological sites were identified.

A total of 251 assessed sites have been documented within the LAA, 184 of which are lithic scatters with less than 100 artifacts typically containing only artifacts made from black chert, including 57 sites where only a single artifact has been located. Thirty-one sites contain one or more of the following: a variety of artifact types, multiple raw materials, stratified deposits with multiple occupations, or faunal remains. Based on these characteristics, the 31 sites are considered to have higher scientific significance in accordance with Appendix D of the *British Columbia Archaeological Impact Assessment Guidelines*.

For the purposes of this assessment, these more complex sites have been labeled “Class I” sites (n = 31) while the low density lithic scatters containing only artifacts made from black chert are considered “Class II” sites (n = 210). These site classes are based on their assessed scientific significance, and they are linked to potential mitigation measures.

Ten sites could not be classified as either Class I or II, based on existing information. These locations have been included in archaeological overview level assessments, but insufficient information is currently available to assign these locations to classes until such time as field-level assessments occur. They include one site within the dam site, two sites on access roads, and seven sites within quarried and excavated construction materials areas.

Archaeological work has addressed the requirements of the *Canadian Environmental Assessment Act* 2012 in that archaeological resources were assessed in relation to the mandates, objectives, and intents of existing legislation and policies at the federal, provincial, and municipal levels of government. In the absence of specific federal guidelines for the protection of archaeological resources, assessment of archaeological resources required by the CEA Agency generally need to meet the requirements of existing provincial legislation. In this case, the B.C. *Environmental Assessment Act* requires an assessment of Project effects upon archaeological

resources, which is typically achieved by conducting an archaeological impact assessment in accordance with BC Archaeology Branch standards. An archaeological impact assessment is underway that is consistent with BC Archaeology Branch standards, the B.C. *Heritage Conservation Act* (Permit 2010-0378), and a Memorandum of Understanding signed by three Treaty 8 First Nations (Doig River First Nation, Prophet River First Nation, and West Moberly First Nations) and the Province which refers directly to heritage conservation.

Historical Resources

A review of historical background data was conducted and included examining information concerning local and regional history as it relates to historical sites in the LAA, including written, cartographic, and photographic documents from published and unpublished sources. Field investigations at known historical sites and interviews with stakeholders were completed. Interviews provided an understanding of what historical resources are valued within the LAA, and why they are important. As well, participants were asked to identify sites, places, buildings, or other resources of historical or heritage importance in the LAA that reflect their values and ideas of heritage. Thirty-eight stakeholders were invited to participate in interviews, and twenty-two accepted. Six of the interviews included subsequent visits to historical site locations.

The field inventory and assessment of historical resources focused on areas with potential for historical remains, including previously recorded historical sites and locations identified during the review of existing information, from reconnaissance surveys, during the archaeological field program, and those identified by stakeholders. Fifty locations were examined from the area south of Fort St. John to west of Hudson's Hope, and 187 subsurface tests were excavated during the historical field assessment.

Based on the field inventory and stakeholder interviews, 42 historical sites have been identified within the heritage resources LAA. The 42 sites consist of Rocky Mountain Fort, Rocky Mountain Portage House, Rocky Mountain Portage Trail, former homesteads or other habitation sites including collapsed or partially standing structures, industrial or agricultural sites and associated artifacts, a wagon road, two trails, two unregistered cemeteries, a ferry landing, a canoe skid, a wagon wheel, and physiographic landscape features.

Site HbRf-31 (Rocky Mountain Fort) was revisited and general site observations were made, but no assessment work was conducted as part of this program as extensive excavations have been previously completed at the site. Permission to access six other sites on private property, including HaRl-4 (Rocky Mountain Portage House) was not granted for the field program.

Also of note, in 1998, the Peace River was recognized as a provincial heritage river by British Columbia's Heritage River Program. Specifically, it has been recognized as a working river that "integrates economic activities with natural heritage, recreational, historic, and traditional cultural values". The Province's vision statement seeks to manage resource-based uses of the river while maintaining representative natural heritage qualities and recognizing the historical heritage values of the river corridor to Aboriginal and non-Aboriginal people.

In the broader context, the cultural landscape of the Peace River region, comprised of the river valley and its associated uplands is also noted. Parks Canada defines cultural landscapes as "any geographical area that has been modified, influenced, or given special cultural meaning by people". In this context, the Peace River region is both a cultural landscape and a rural historical landscape.

For the purposes of this assessment, those historical sites identified as having significance and with good integrity and condition are considered "Class I" historical sites (*n* = 9). Those sites assessed as having significance, but poor integrity and condition are identified as "Class II" sites (*n* = 21). "Class III" sites (*n* = 8) are those with low significance and poor integrity and condition. These site classes are linked to potential mitigation measures. No data were collected at four additional sites, which could not be accessed during the field inventory.

Historical resource assessment work has addressed the requirements of the *Canadian Environmental Assessment Act* 2012 in that historical resources were assessed in relation to the mandates, objectives, and intents of existing legislation and policies at the federal, provincial, and local levels of government. In the absence of specific federal legislation for the protection of historical resources, assessment of historical resources required by the CEA Agency generally need to meet the requirements of existing provincial legislation. Specifically, the B.C. *Environmental Assessment Act* requires an assessment of Project effects upon historical resources, which can be achieved by conducting an impact assessment in accordance with BC Archaeology Branch standards. A historical resources impact assessment was completed that is consistent with BC Archaeology Branch standards, the B.C. *Heritage Conservation Act*, as well as the Memorandum of Understanding signed by three Treaty 8 First Nations (Doig River First Nation, Prophet River First Nation, and West Moberly First Nations) and the Province which refers directly to heritage conservation. Historical resources that do not fall under the protection of the B.C. *Heritage Conservation Act* were also considered, consistent with internationally recognized best practice.

Credits

Project Director:	Robert McLenehan, P.Eng., Golder Associates Ltd.
Project Managers:	D'Arcy Green, B.Ed., M.A., Golder Associates Ltd. Andrew Mason, M.A., RPCA, Golder Associates Ltd. Gail Wada, B.A., RPCA, Golder Associates Ltd.
Project Co-ordinators:	Pamela Di Scianni, B.Mgt., Golder Associates Ltd. Christine Zielke, AMEC Environment & Infrastructure
Technical Advisors:	Arnoud Stryd, Ph.D., RPCA, AMEC Environment & Infrastructure
Heritage Inspection Permit Holder:	Diana Alexander, M.A., RPCA, AMEC Environment & Infrastructure
Palaeontological Resources Lead:	Edward H. Davies, Ph.D., P.Geol., Branta Biostratigraphy Ltd.
Archaeological Resources Lead:	Diana Alexander
Historical Resources Lead:	Doris Zibauer, M.A., RPCA, Golder Associates Ltd.
Archaeological Predictive Modeling Lead:	Morley Eldridge, M.A., RPCA, Millennia Research Ltd.
Archaeological Predictive Modeling:	Morley Eldridge Alyssa Parker, B.Sc., Millennia Research Ltd.
Erosion Potential Assessment Sorting Technique:	Rowland Atkins, M.Sc., P.Geo., Golder Associates Ltd. Jonathan Seabrook, B.Sc.,G.I.T., Golder Associates Ltd
Palaeontological Assessment:	Edward H. Davies Catherine Biollo, B.Sc., Branta Biostratigraphy Ltd. David Mazzuchi, Ph.D., Branta Biostratigraphy Ltd. Samuel Wilson, M.Sc., Branta Biostratigraphy Ltd. Kevin Kruger, B.Sc., Branta Biostratigraphy Ltd. Darla Zelenitsky, Ph.D., Branta Biostratigraphy Ltd.
Archaeological Field Coordinators:	Matt Begg, B.A., RPCA, AMEC Environment & Infrastructure D'Arcy Green Garrett Hendricks, B.A., AMEC Environment & Infrastructure Anita Swallow, M.Sc., AMEC Environment & Infrastructure

Archaeological Field Crew:

Alveena Acko
Corey Acko
Edna Acko
Jordie Acko
Robin Acko
Starr Acko
Preston Adekat
Trevor Adekat
Elysia Allen
Eric Anderson
Neil Anderson
Herbert (Gordon) Andre
Harriet Appaw
Amber Apsassin
Brenda Apsassin
Colleen Apsassin
Courntall Apsassin
Craig Apsassin
Dylan Apsassin
Geoffrey Apsassin
Herbie Apsassin
Henry Apsassin
Jeffery Apsassin
John Apsassin
Kyla Apsassin
Ricky Apsassin
Riley Apsassin
Ruby Apsassin
Stephanie Apsassin
Troy Apsassin
Tyson Apsassin
April Askoty
Carla Askoty
Janice Askoty
Bernice Attachie
Jessie Attachie
Wyatt Attachie
Chris Baker, M.Sc.
Irma Bartlett
Willie Becker
Matt Begg
Dale Belcourt
Gordon Belcourt
Kyle Belcourt-Gladue
Scott Belcourt
Kim Berg, B.A.
Catherine Biollo
Tarilee Beyak, B.Sc.
Michelle Bissonnette, M.A.
Ryan Blackburn, B.A.
Steven Blue
Graham Bowles, B.A.
Anna Brace, M.A.B.A.
Dawn Bradley, M.Sc.
Michael Brand, Ph.D.
Eva Brooke, B.A., RPCA
Larry Brown
Evan Calliou
Gary Calliou
Lance Cardinal
Melvin Cardinal
Hayley Chester, B.A.
Douglas Chingee
Barb Chipesia
Chris Chipesia
Darcy Chipesia
Jeffery Chipesia
Kerry Chipesia
Kim Chipesia
Leon Chipesia
Nancy Chipesia
Nicole Chipesia
Richard Chipesia
Rodney Chipesia
Sheldon Chipesia
Kimberly Christenson, M.Sc., RPCA
Clinton Coates, B.A., RPCA
Dana Dalmer, B.A., RPCA
Edward Davies
Alvina Davis
Carol Davis
Drew Davis
Kelvin Davis
Korbin Davis
Maxine Davis
Todd Davis
Tyrone Davis
Vanessa Davis
Cheryl Denley, M.Sc., B.A.
Ashley DeYoung, B.A.
Ryan Dickie, M.A.
Chris Dodd, B.A. RPCA
Tim Duke
Jacob Earnshaw, B.A.
Andrew Eckert
Roger Eldridge, B.A.
Kirsten Eves, B.Sc.
Rob Field, B.A., RPCA
Victor Field
Dallas Ferguson
Eric Ferguson
David Fox
Sandra Fuchs
Adam Gamble
Geraldine Gauthier
Jack Gauthier
Myron Gauthier
Thomas Gauthier-Lazot
Jeremy Ghostkeeper
Rhory Gillies, B.A.
Craig Gladue
Laurian Gladue
Warren Gladue
Chelsea Gogal, B.A.
Dallas Gomolchuk
Trevor Gonwick
Rebecca Goodwin, B.A.
Conan Gradson
David Graff
Bella Gravelle
Ashley Grey
Denelle Greyeyes
Debbie Hansen
Beatrice Harding
Mable Harding
Katie Hausch, B.A. (Hons.)
Garrett Hendricks
Damian Hind, M.A.
Trevor Hoffman
Lee-Anne Howes
Dallas Hunter
Calvin Inyallie
Dionne Izony
Linnea Izony

Lyndsey Jack, M.A.
Junior Robert Jackson
Rick James, B.G.S.
Sarah Kavanagh, M.Sc.
Marlowe Kennedy, B.A.
Brent Kevinsen, B.Sc.
Joel Kinzie, B.A., RPCA
Shauna Kirby, B.A.
Alan Korejbo, M.A.
~~Kevin Kruger, B.Sc.~~
Graham Lantz, B.A.
Kyle Leney
Morgan Letendre
Shirley Letendre
Cheryl Lilly
Bernice Lilly
Lori Lineham
Nellissa Ling, B.A. (Hons.)
Simon Lloyd-Price, B.A.
Tyson Logan
Andrew Mason
Ronnie McCook
Ramsay McKee, B.A.
Adrienne Marr, B.A., RPCA
Nola Markey, Ph.D. Cand., RPCA
Adam Love
Brian Meck
Grace Metecheah
Les Miller, B.A.
Charles Moore, M.A., RPA, RPCA
Galen Morris, B.A.
Phoebe Murphy, M.A., B.A.
Adrian Myers, M.A.
Blanche Napoleon
Robert Napoleon
Alexander Nascou, M.A.
Michael Olivotto, M.A.
Robin Olsen
Derek O'Neill, B.A.
~~J. Casey O'Neill, B.Sc. (Hons.), RPCA~~
Juritha Owens
Jonathon Patenaude
Todd Paquin, M.A., RPCA
Nova Pierson, M.A.
Derek Pouce Coupe
Nina Polujanski, B.Sc.
Maggie Poirier, B.A.
Wilma Pyle-Becker
Josephene Pynadath, B.A.
Devin Rachar
Gary Reno
Jerram Ritchie, B.A.
Ted Roberts
Bev Rohel
Douglas Ross, Ph.D.
Michael Ross, B.A.
Peter Ross, M.A.
Jeremiah Sark
Linda Sark
Olivia Savard
Crystal Sawyer, B.A.
Marina Schierer
Jeff Shaughnessy, B.A.
Wilfred Sheldon
Nicole Slade, B.A.
Naomi Smethurst, B.A.
Sarah Smith, B.A., RPCA
Verne Solonas
James Soriano
Linden Stoney
Ron Stoney
Summer Stoney
Jeff Stott, B.A.
Ian Streeter, M.A., RPCA
Michael Strong
Anita Swallow, M.Sc.
Grant Takasaki
Michael Taylor, M.A.
Ashley Testawits
David Testawits
Malcolm Testawits
Vashti Thiesson, B.A.
Lenore Thompson, B.A.
Vishal Toora
Troy Tzakoza
Chris Verral, B.A.
Ben Vickers-Redhead, B.A.
Calvin Vaughn
River (Derek) Walker
Vince Warner, B.A.
Brock Wiederick, B.A.
Achinie Wijesinghe, B.A.
Curtis Wokeley
Lori Wokeley
Fabian Wolf
Maurice Wolf
Devon Wolfe
Gilbert Wolfe
Ralph Wolfe
Troy Wolfe
Chris Wylie, M.A.
Danny Yahey
Georgina Yahey
Michael Yahey
Randy Yahey
Tyler Yahey
Tenisha Yahey
Tianna Yahey
Meng Ying, M.A.
~~Darla Zelenitsky, Ph.D.~~

Historical Heritage Resources Assessment:

Michael Brand, AMEC Environment & Infrastructure
Linda Mattson, Ph.D., Golder Associates Ltd.
Laura Pasacreta, M.A., Donald Luxton & Associates Inc.
Douglas Ross, Ph.D., AMEC Environment & Infrastructure
Sandi Ratch, M.A., Donald Luxton & Associates Inc.
Doris Zibauer

Data Management:	Colin Bakermans, B.Sc., Adv. Dipl. GIS, Golder Associates Ltd. Matt Begg Bonnie Campbell, B.A. Dip. T., RPCA, Golder Associates Ltd. Angel LeBlanc, Dipl. GIS, Dipl. Bio Sc., Golder Associates Ltd. Garrett Hendricks Nina Polujanski, B.Sc., AMEC Environment & Infrastructure Chris Wylie
GIS Analysts:	Colin Bakermans Kendra Gibbons, B.A., Cert. GIS, AMEC Environment & Infrastructure Angel LeBlanc Alyssa Parker Jonathan Pokotylo, BSc., Dipl., Golder Associates Ltd. David Cook, B.Sc., Golder Associates Ltd. Geoff Mulligan, B.Sc., GIS, Golder Associates Ltd. Leigh Durland, Golder Associates Ltd.
Post-Field Palaeontological Analysts:	Ed Davies
Post-Field Lithic Analysts:	Ryan Dickie, M.A., AMEC Environment & Infrastructure Wilma Becker-Pyle
Post-Field Faunal Analyst:	Nova Pierson, M.A., AMEC Environment & Infrastructure
Post-Field Analysis:	Ashley DeYoung, B.A., AMEC Environment & Infrastructure Tarilee Beyak, B.Sc., AMEC Environment & Infrastructure Kirsten Eves, B.A., AMEC Environment & Infrastructure Brent Kevinsen, B.A., AMEC Environment & Infrastructure Michael Olivotto, M.A., AMEC Environment & Infrastructure
Senior Technical Reviewers:	Diana Alexander D'Arcy Green Andrew Mason Jeff Bailey, M.A., RPCA, Golder Associates Ltd.
Senior Report Authors:	Diana Alexander Richard Brolly, B.A., RPCA, AMEC Environment & Infrastructure Edward Davies Morley Eldridge Arnoud Stryd Doris Zibauer

Additional Report Authors:

Jeff Bailey
Clinton Coates, B.A., RPCA, Golder Associates Ltd.
Matt Begg
Ryan Dickie
John Emery, AScT, AMEC Environment & Infrastructure
D'Arcy Green
Ben Hjermstad, M.A., Golder Associates Ltd.
D. Geordie Howe, B.A. RPCA, AMEC Environment & Infrastructure
Nola Markey, Ph.D. Cand., RPCA, Golder Associates Ltd.
Andrew Mason
Linda Mattson
J. Casey O'Neill
Alyssa Parker
Nova Pierson
Nina Polujanski
Simon Solomon, M.A., AMEC Environment & Infrastructure

Reporting Assistants:

Michelle Bissonnette, M.A., AMEC Environment & Infrastructure
Aidan Burford, B.Sc., RPCA, AMEC Environment & Infrastructure
Melissa Cutting, B.A., AMEC Environment & Infrastructure
Cheryl Denley, M.Sc.
Ashley DeYoung
Olivia Dodd, B.A., Golder Associates Ltd.
Kirsten Eves
Arran Ferguson, B.A., AMEC Environment & Infrastructure
Michael Fox, B.A., AMEC Environment & Infrastructure
Sarah Gamble, B.A., AMEC Environment & Infrastructure
Erin Hannon, B.A., AMEC Environment & Infrastructure
Garrett Hendricks
Robert MacNevin, B.A., AMEC Environment & Infrastructure
Galen Morris, B.A., AMEC Environment & Infrastructure
Michael Olivotto
Heather Pratt, M.A., RPCA, Golder Associates Ltd.
Natasha Reaney, M.Pl., Golder Associates Ltd.
Peter Ross, M.A., AMEC Environment & Infrastructure
Anita Swallow
Paula Thorogood, B.A., RPCA, AMEC Environment & Infrastructure

Site Inventory Forms:

Melissa Cutting
Simon Solomon
Garrett Hendricks
Nina Polujanski

Report Preparation

Raelene Danks, Golder Associates Ltd.
Arlene Dioquino, Golder Associates Ltd.
Jennifer Ellis, Golder Associates Ltd.
Claire Fossey, Golder Associates Ltd.
Lindsay Jones, Golder Associates Ltd.
Yudi Sönnichsen, Golder Associates Ltd.
Dustin Villeneuve, Golder Associates Ltd.

Aboriginal Communities Engagement:

John Emery
Ben Hjermstad
Anita Swallow
Sandra Witt, B.A., AMEC Environment & Infrastructure

Resource Information Standards Committee Training Team:

Nola Markey
Kim Berg, B.A., AMEC Environment & Infrastructure
Anita Swallow

Health and Safety Coordinators:

Richard Day, M.A.Ed, CRSP, AMEC Environment & Infrastructure
Kori Gryschuk, CHSC, Golder Associates Ltd.
Don Kennett, CRSP, Golder Associates Ltd.
Christine Zielke

Abbreviations and Acronyms

AIA ..... Archaeological Impact Assessment
BCEAA ..... British Columbia Environmental Assessment Act
BCEAO ..... British Columbia Environmental Assessment Office
BP ..... Before Present
CEAA ..... Canadian Environmental Assessment Act
CEA Agency ..... Canadian Environmental Assessment Agency
CIFSA ..... Cremation, Interment, and Funeral Services Act
CMT ..... Culturally Modified Tree
DBS ..... Depth Below Surface
DEM ..... Digital Elevation Model
EIS ..... Environmental Impact Statement
E-PAST ..... Erosion Potential Assessment Sorting Technique
GIS ..... Geographic Information System
GPS ..... Global Positioning System
HCA ..... Heritage Conservation Act
LAA ..... Local Assessment Area
LiDAR ..... Light Detection and Ranging
MASL ..... Metres Above Sea Level
MOU ..... Memorandum of Understanding
NAD ..... North American Datum
NTS ..... National Topographic System
OGC ..... Oil & Gas Commission (of British Columbia)
PHR ..... Provincial Heritage Register
PI ..... Point of Intersection
RAA ..... Regional Assessment Area
ST ..... Shovel Test
TIF ..... Tagged Image File
UTM ..... Universal Transverse Mercator
VC ..... Valued Component

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1.0 INTRODUCTION

This report describes the results of a heritage resource assessment of the proposed BC Hydro Site C Clean Energy Project (the "Project") (Volume 4, Section 32 Heritage Resources Effects Assessment, Figure 32.1). The heritage resource assessment is a multi-year integrated study comprising assessments of palaeontological, archaeological, and historical resources that may be affected by the Project.

The Project requires environmental certification and regulatory approvals prior to construction. Heritage resource assessment field work was conducted in accordance with British Columbia *Heritage Conservation Act* Permit 2010-0378 (amended on May 24, 2011, February 7, 2012, and February 10, 2012). The palaeontological and most of the historical field work did not require permits, with the exception of historical sites captured under the British Columbia *Heritage Conservation Act*. Work carried out at these locations was in accordance with British Columbia *Heritage Conservation Act* Permit 2010-0378.

The activities discussed in this report were conducted by a consortium of consultancies (the "Golder team"), including Golder Associates Ltd., AMEC Environment & Infrastructure (Archaeology & Cultural Heritage Resources), Millennia Research Ltd., Branta Biostratigraphy Ltd., and Donald Luxton & Associates Inc.

1.1 Scope of Heritage Assessment Program

The goal of the heritage field program was to describe the locations and characterize the nature of heritage resources within the Local Assessment Area (LAA), such that potential project effects on those resources could be assessed. Building upon existing baseline information, additional heritage resources field inventory was undertaken in 2010, 2011, and 2012. This technical appendix summarizes heritage resources baseline conditions in support of Volume 4, Section 32 Heritage Resources Effects Assessment.

1.2 Format

This report is organized as follows. Section 1 introduces the Project, outlines the scope of work and summarizes the heritage program objectives. Section 2 provides an overview of Aboriginal involvement in the heritage program, including archaeological training opportunities and participation in the archaeological field studies. Section 3 summarizes information on the biophysical and cultural setting of the LAA, including a description of the geology, vegetation, wildlife, past environments, culture history, and traditional use of the LAA. Section 4 describes palaeontological research methods and results, while Sections 5 and 6 do the same for archaeological and historical resources. The methods used to evaluate the heritage significance of palaeontological, archaeological, and historical resources are discussed in Section 7 along with the results of these evaluations. Potential mitigation approaches are provided in Section 8. A summary of the heritage program is provided in Section 9. Study limitations, directions regarding use of the report and a closure statement are presented in Section 10.

Several appendices provide detailed data to support the report text. Appendix A presents a glossary of technical terms. Appendix B is a user's manual for the Cartopac tool. Appendix C provides a table of palaeontological site significance, Appendix D is a summary of known palaeontological species according to geological formation, and Appendix E summarizes the results of the palaeontological program. Appendix F provides a detailed description

of each identified archaeological site, and Appendices G and H present x-ray fluorescence and radiocarbon dating analyses for archaeological materials. Site specific scientific significance assessments for archaeological sites are tabulated in Appendix I. Descriptions of historical sites are provided in Appendix J, followed by copies of two stakeholder questionnaires in Appendix K. Appendix L is a summary of information derived from historical aerial photographs, and Appendices M-1 and M-2 provide site specific assessments of erosion potential for archaeological and historical sites. Photographs for the palaeontology, archaeology and historical programs are provided in Appendix N, which is divided into three subsections.

2.0 ABORIGINAL INVOLVEMENT

Aboriginal participation was important to the overall success of the heritage assessment program. Aboriginal communities and organizations with asserted interests in the vicinity of the Project area were provided several avenues to contribute to the assessment, including review of the British Columbia *Heritage Conservation Act* permit application and associated archaeological field analysis, and reporting methodologies, sub-contracting opportunities, direct employment on the archaeological field crew, and input to the mitigation plan. Aboriginal communities were also provided with the opportunity to have their members participate in archaeological field certification training.

2.1 Aboriginal Participants in the Heritage Assessment

During their review of the British Columbia *Heritage Conservation Act* permit application, the BC Archaeology Branch identified the following Aboriginal communities and organizations as having potential interests in the Project area: Blueberry River First Nations, Doig River First Nation, Fort Nelson First Nelson, Halfway River First Nation, Kelly Lake Cree Nation, McLeod Lake Indian Band, Prophet River First Nation, Saulteau First Nations, Treaty 8 Tribal Association, and West Moberly First Nations. Prior to the 2012 field program, the BC Archaeology Branch included the Dene Tha' in the request to First Nations for review and comment on proposed amendments to British Columbia *Heritage Conservation Act* permit 2010-0378. Doig River, Halfway River, Prophet River, and West Moberly First Nations are currently affiliated with the Treaty 8 Tribal Association, a regional Aboriginal organization with an office in Fort St. John (Treaty 8 Tribal Association 2010). While the Blueberry River First Nations, Saulteau First Nations, Fort Nelson First Nation, and McLeod Lake Indian Band are British Columbia signatories to Treaty No. 8, they are not members of the Treaty 8 Tribal Association (Treaty 8 Tribal Association 2010). The Dene Tha' First Nation is an Alberta signatory to Treaty No. 8 and is not affiliated with the Treaty 8 Tribal Association. The Kelly Lake Cree Nation is neither a signatory to Treaty No. 8, nor a member of the Treaty 8 Tribal Association.

At the request of BC Hydro, the following Aboriginal communities were also engaged in the heritage program: Duncan's First Nation, Horse Lake First Nation, Kelly Lake Métis Settlement Society, Kwadacha Nation, and Tsay Keh Dene. Duncan's First Nation and Horse Lake First Nation are Alberta signatories to Treaty No. 8.

2.2 Aboriginal Review of the British Columbia *Heritage Conservation Act* Permit Application

The BC Archaeology Branch forwarded the British Columbia *Heritage Conservation Act* permit application to the following Aboriginal communities and organizations: Blueberry River First Nations, Doig River First Nation, Fort Nelson First Nelson, Halfway River First Nation, Kelly Lake Cree Nation, McLeod Lake Indian Band, Prophet River First Nation, Saulteau First Nations, Treaty 8 Tribal Association, and West Moberly First Nations. These communities and associations were provided 30 days to review and comment on the proposed methods to be employed during the field work, analysis, and reporting stages of the archaeology program. At the request of some communities, the BC Archaeology Branch extended the 30 day deadline to allow further review of the application.

2.3 Resource Information Standards Committee Training

At the request of BC Hydro, the Golder team offered Resource Inventory Standards Committee (RISC) training in archaeological field methods to Aboriginal community members engaged in the heritage program. In August and September of 2010, prior to the initiation of field work, three sessions of a 5-day RISC certification course in archaeological field methods were delivered in Fort St. John. Two additional 2-day RISC certification courses were delivered for Aboriginal community members that participated in the 2011 field work; these two courses were conducted in Fort St. John in November 2011 at the conclusion of the 2011 field season.

All of the Aboriginal communities identified in the British Columbia *Heritage Conservation Act* permit and by BC Hydro as having potential interests in the LAA were invited to participate in the training. All except the Prophet River and West Moberly First Nations provided trainees. The number of trainees from each community is summarized in Table 2.1. In total, 76 Aboriginal community members representing 11 communities were provided with RISC training: 53 in 2010 and 23 in 2011.

Table 2.1: Aboriginal Resource Inventory Standards Committee training participation

Aboriginal Community	2010 Trainees	2011 Trainees	Total Trainees
Blueberry River	11	2	**13**
Doig River*	0	16	**16**
Duncan's	6	0	**6**
Fort Nelson	0	1	**1**
Halfway River*	0	1	**1**
Horse Lake	5	1	**6**
Kelly Lake Cree	4	1	**5**
Kelly Lake Métis Settlement Society	4	0	**4**
Kwadacha	2	0	**2**
McLeod Lake	0	1	**1**
Prophet River*	0	0	**0**
Saulteau	19	0	**19**
Tsay Keh Dene	2	0	**2**
West Moberly*	0	0	**0**
TOTAL	**53**	**23**	**76**

NOTE:
* Member of the Treaty 8 Tribal Association

The training addressed pertinent milestone concepts of the RISC program and specific training needs of the archaeological field program. The following topics were addressed during the training in either classroom or applied format and outlined in a manual provided to each participant:

- General archaeological and environmental background
- The British Columbia *Heritage Conservation Act* and permitting system
- The Remote Access to Archaeological Data (RAAD) online tool for accessing the Provincial Heritage Register

- Archaeological assessment, monitoring, and mitigation programs
- Culturally modified trees (CMTs)
- Compass and map orientation and archaeological site mapping
- Field reconnaissance and shovel testing
- Archaeological site identification and data recording
- Artifact identification
- Archaeological site recording forms

In addition, the participants were provided with a tour of the Fort St. John – North Peace Museum to gain familiarity with regional heritage materials. At the end of each session, the participants were tested on the topics outlined above. All of the participants successfully passed the course.

Of the 76 individuals who successfully completed the RISC training program, 58 (76.3%) were subcontracted or directly hired for field assistant positions on the field program.

2.4 Aboriginal Involvement in Archaeology Field Program

Golder signed Subconsulting Agreements with all but three of the above-noted Aboriginal communities or affiliated Aboriginal businesses to provide community assistants to participate in the archaeological field work. This structure provided an opportunity to increase capacity within the Aboriginal communities, while providing monetary benefits to Band offices or affiliated businesses for managing the hiring process. Community members from the McLeod Lake Indian Band were hired directly by Golder.

Employment opportunities in the 2010 and 2011 field programs were first offered to Aboriginal community members who had successfully completed the RISC Training course, or who had equivalent archaeological experience. For the 2012 field season, preference was given to community members who also had successfully participated in the 2010 or 2011 field seasons. This was done in part to provide some consistency in the methods used during the field work, knowing that these assistants had been previously trained in archaeological methods, had established an aptitude for conducting the field work, and had demonstrated a familiarity with the particular assessment requirements of the Project.

Table 2.2 provides a summary by year of the Aboriginal communities who participated in the archaeological field program, including the number of assistants employed from each of the Aboriginal communities. Table 2.3 is a summary by year of the number of person days worked from each Aboriginal community. Duration of employment for individuals ranged from 1 day to a maximum of 140.5 days. In total, the 163 different Aboriginal community members worked the equivalent of 3,708.5 person days over the last three years (Tables 2.2 and 2.3).

Table 2.2: Summary of the number of Aboriginal assistants employed

Aboriginal Community	2010	2011	2012	Total
Blueberry River	8	48	12	51
Doig River*	0	26	13	26
Duncan's	4	7	4	12
Fort Nelson	0	1	1	1
Halfway River*	0	7	3	8
Horse Lake	4	5	5	7
Kelly Lake Cree	2	7	2	9
KLMSS	3	6	2	9
Kwadacha	2	2	1	2
McLeod Lake	0	3	2	3
Prophet River*	0	12	4	15
Saulteau	8	13	6	18
Tsay Keh Dene	0	2	0	2
West Moberly*	0	0	0	0
TOTAL	**31**	**139**	**55**	**163**

NOTE:
* Member of the Treaty 8 Tribal Association

Table 2.3: Summary of person days of employment for Aboriginal field assistants

Aboriginal Community	2010	2011	2012	Total
Blueberry River	102	430.5	168	700.5
Doig River*	0	409.5	178.5	588
Duncan's	59	155.5	135	349.5
Fort Nelson	0	57	63.5	120.5
Halfway River*	0	103	80.5	183.5
Horse Lake	45	211	90.5	346.5
Kelly Lake Cree	12	121.5	53	186.5
KLMSS	23	88.5	54	165.5
Kwadacha	19	50	51.5	120.5
McLeod Lake	0	136.5	106	242.5
Prophet River*	0	111	56.5	167.5
Saulteau	90	256	150.5	496.5
Tsay Keh Dene	0	41	0	41
West Moberly*	0	0	0	0
TOTAL	**350**	**2171**	**1187.5**	**3708.5**

NOTE:
* Member of the Treaty 8 Tribal Association

Table 2.4 summarizes the fees and administration charges provided by year to each of the Aboriginal subconsultants, as well as the wages earned by the McLeod Lake Indian Band members who were hired directly by Golder. In total, Aboriginal groups received over $1.28 million in direct benefits (primarily wages). In addition, over $500,000 in expenses were spent on Aboriginal participation over the three year field program. These included travel and meal disbursements expensed by the Aboriginal subconsultants, as well as the hotel and meal expenses managed by the Golder team. Disbursement costs varied between Aboriginal groups depending mainly on whether community assistants were able to work from their own homes or were provided with accommodation and meals. Not included in these disbursements are the field equipment expenses covered by the Golder team, including vehicles and personal protective equipment.

Table 2.4: Summary by year of Aboriginal group fees and administration charges

Aboriginal Community	2010	2011	2012	Total
Blueberry River	$35,588	$150,201	$58,615	$244,404
Doig River*	N/A	$142,875	$62,279	$205,153
Duncan's	$20,585	$54,254	$47,102	$121,941
Fort Nelson	N/A	$19,887	$22,155	$42,042
Halfway River*	N/A	$35,937	$28,086	$64,023
Horse Lake	$15,701	$73,618	$31,575	$120,894
Kelly Lake Cree	$4,187	$42,391	$18,492	$65,070
KLMSS	$8,025	$30,878	$18,841	$57,743
Kwadacha	$6,629	$17,445	$17,968	$42,042
McLeod Lake	N/A	$40,950	$31,800	$72,750
Prophet River*	N/A	$38,728	$19,713	$58,441
Saulteau	$31,401	$89,318	$52,509	$173,229
Tsay Keh Dene	N/A	$14,305	N/A	$14,305
West Moberly*	N/A	N/A	N/A	N/A
TOTAL	**$122,115**	**$750,787**	**$409,135**	**$1,282,037**

NOTE:
N/A – not applicable

All of the Aboriginal assistants were provided with a safety and field program orientation. Most orientations took place on the first day of the field season, but to accommodate new workers, orientations were also offered when participants joined the field team during the field season. Safety equipment such as hard hats and high-visibility vests were supplied as needed. All Aboriginal field assistants were required to conform to Golder's and BC Hydro's health and safety protocols.

The field program provided Aboriginal assistants with opportunities to meet the following objectives:

- Provide regular feedback to their communities on the results of the archaeological impact assessment
- Apply recently acquired RISC training knowledge
- Increase archaeological field skills

- Augment employment experience
- Visit, or revisit, parts of their traditional territories not seen before or for many years
- Network with the archaeological community and other potential employers
- Earn seasonal income
- Provide Aboriginal communities and affiliated businesses with subcontracting opportunities

Aboriginal community assistants contributed greatly to the success of the heritage assessment field program. The Golder team involved Aboriginal workers in key decisions related to the archaeological field work through the duration of the field program. Their contributions included sharing local knowledge of access routes and trail systems, conducting surface reconnaissance, excavating shovel tests, screening excavated soils for artifacts, and assisting with archaeological field data recording, orienteering, and mapping.

3.0 BIOPHYSICAL AND CULTURAL SETTING

The following sections describe the natural and cultural environment of the LAA as they relate to heritage resources. The geological setting is discussed primarily in terms of the potential for fossil occurrences. The late Pleistocene and early Holocene palaeoenvironment and modern environment are discussed in relation to their influence on human use of the landscape and the resulting implications for the existence and preservation of archaeological and historical sites.

More detailed discussions of the physiography and topography of the LAA are presented in Volume 2 Section 11.2 Geology, Terrain Stability and Soils, and in Volume 2 Appendix B Geology, Terrain Stability and Soil Reports. Vegetation is discussed in Volume 2 Section 13 Vegetation and Ecological Communities and wildlife in Volume 2 Section 14 Wildlife Resources. Both vegetation and wildlife are assessed in greater detail in Volume 2 Appendix R Terrestrial Vegetation and Wildlife Report.

3.1 Physical Environment

Environmental conditions may favour or inhibit the availability of natural resources available for human subsistence, and as such, the environment was an important factor in determining land use, settlement, and subsistence patterns of Aboriginal peoples. In this section, background information on past and present regional resource characteristics that may have influenced human occupation and land use is summarized to provide a framework for assessing heritage resources in the LAA.

3.1.1 Physiography and Topography

The LAA is situated within the Alberta Plateau, which is characterized by flat to gently rolling plains deeply dissected by the Peace River and its tributaries (Blyth 2008; Holland 1976). The plains have a low continuous slope to the east, although there is a considerable amount of undulating terrain with mounds and saturated hollows (Mathews 1978). Maximum relief in the LAA is approximately 250 m, ranging from typically 400 to 650 m above sea level (masl). The terrain within the Peace River Lowlands is typified by fluvial, glacial, and interglacial deposits of Quaternary age that may be up to 400 m thick in places (Volume 2 Section 11.2 Geology, Terrain Stability and Soils and Volume 2 Appendix B Geology, Terrain Stability and Soil Reports). These deposits mask much of the Cretaceous-aged bedrock topography (Severin 2004) present throughout the LAA.

The Peace River crosses and drains the LAA within a broad, flat-floored valley that measures approximately 3.5 km wide and about 200 m deep within the LAA (Mathews 1978). The present-day river channel varies from 0.5 to 1 km wide within this valley. Between Peace Canyon Dam in the west and the Site C dam site in the east, the Peace River lies at an elevation of approximately 460 masl.

Terrain within the LAA has been largely created by the down-cutting of the Peace River and its tributaries into fluvial, glacial and interglacial deposits and underlying sedimentary bedrock. Geomorphic processes have included, and continue to include, various forms of mass movement, fluvial deposition and erosion, and aeolian erosion and deposition.

For the most part, the Peace River follows a historical interglacial river valley (Severin 2004). After the end of the most recent glaciation, small ice-dammed lakes drained to create the modern Peace River valley, which downcut

rapidly during the Upper Pleistocene (13,970 to 10,000 years Before Present [BP]). Broad fluvial terraces were formed following the down-cutting and infilling of each valley. These terraces are common between the present-day floodplain and the valley walls. The terraces are generally elevated less than 50 m above river level (see Volume 2 Section 11.2 Geology, Terrain Stability and Soils). These relict terraces and floodplains have been identified as having potential for archaeological sites, as they offered level ground close to the Peace River.

As indicated in Volume 2 Section 11.2 Geology, Terrain Stability and Soils, 4,010 landslides have been identified in the LAA, 759 (19%) of which were classified as less than 100 years old, while 3,251 (81%) were classified as greater than 100 years old. Many of these landslides are interpreted as having occurred in the Upper Pleistocene within a short period of time after deglaciation. The oldest slide identified by BGC (2012) through radiocarbon dating (sample PN-525) may have occurred approximately 9,300 BP.

The effects of landslides on human occupation and archaeological site potential may vary. For example, archaeological materials located on a terrace edge at the top of a slide may be removed, mixed, and re-deposited at a lower elevation during a slide event. Alternatively, sites located below a slide may be buried by debris, making them difficult to locate using archaeological methods, or may be intermixed with material from above. In some cases, older slide deposits may have created a landform, such as a fan, that was favourable to human use, which might indicate elevated archaeological site potential.

3.1.2 Bedrock Geology

The LAA is underlain by Upper and Lower Cretaceous sedimentary rocks of the Fort St. John Group and includes a number of formations that are part of the Dunvegan Formation. The Fort St. John Group consists of sandstones and shales belonging to the Shaftsbury Formation, Boulder Creek Formation, Hulcross Formation, Gates Formation, or Moosebar Formation. Further discussion of bedrock and surficial geology in the context of palaeontological resources is presented in Section 4.2.1.2 below.

3.1.2.1 Surface Geology

Surficial geological conditions in the LAA consist of a sequence of fluvial, glacial, and interglacial deposits up to 400 m thick. Typically, the youngest sediments fill the present Peace River valley and the oldest sediments occur on the higher terraces, plateaus, and hills. In Volume 2 Section 11.2 Geology Terrain Stability and Soils, BGC identified a number of overburden units in the LAA, some of which indicate heritage resource potential. Selected units are discussed below.

Fill: As a result of the construction of access roads and highways in the LAA, there are occurrences of anthropogenically disturbed materials. These materials are typically near the surface and consist of dense, well-graded sands, gravels, and cobbles. Archaeological deposits are unlikely to be present in these materials.

Overburden Colluvium: An example of this type of colluvium is the material deposited from the Attachie Slide in 1973 near the Halfway River. The debris still exists on the floodplain today and covers nearly one million square metres and averages 8.5 m thick. Archaeological materials may be present within or below colluvium, where it may be difficult to access. Archaeological or historical sites may exist on top of older colluvial deposits. Steep or unstable colluvium may have low archaeological potential.

Bedrock Colluvium: Bedrock colluvium in the LAA typically originates from the Shaftsbury shale. An example of this in the LAA is at the Cache Creek slide, where debris consists of angular boulders of sandstone in a fine-grained matrix. Archaeological potential associated with bedrock colluvium is generally low due to the blocky nature of the deposits, although potential may be higher on underlying landforms, depending on the age of the colluvial deposit.

Holocene Fluvial Deposits: Floodplains and terraces in the LAA along the Peace River are generally composed of Holocene sands and gravels. The Holocene fluvial deposits have an average thickness of 17 m (Hartman and Clague 2008). These relict terraces and floodplains may have high potential for archaeological sites due to their gentle slope and association with the Peace River.

Laurentide Till: A regional till layer was deposited by Laurentide ice during the last glaciations. Due to its age, Laurentide till should have low archaeological potential, although overlying archaeological materials could extend slightly into upper till deposits.

Cordilleran Till: This deposit of gravel and silty sand is exposed on the lower Halfway River (Hartman and Clague 2008). The till is overlain by either Glacial Lake Mathews sediment or Cordilleran Basin glaciolacustrine and glaciofluvial deposits, depending on the location within the LAA. Similar to Laurentide Till, this unit may have archaeological potential if exposed on shallow slopes.

Upper Paleovalley Fluvial Deposits: This deposit most likely originated from a braided stream that deposited rounded pebble- to cobble-sized gravel with silty clay layers (Hartman and Clague 2008). Clasts typically consist of Cordilleran lithologies such as a quartzite, chert, sandstone, and igneous rocks (Hartman and Clague 2008). Fladmark (1975b as cited in Fladmark 1981) states that local gravels are the source for dull black chert pebbles associated with 90% or more of valley-based archaeological sites in the Peace River region. The chert source indicates that material from this unit may occur in archaeological sites.

3.1.3 Soils

Soils and sediments form the matrix in which archaeological materials are typically preserved. Preservation can be affected by the physical and chemical attributes of the soil. Factors such as temperature, aspect, drainage, and pH can affect the preservation of organic materials in archaeological sites. The generalized descriptions that follow are based on *Soils of the Fort St. John-Dawson Creek Area, British Columbia* (Lord and Green 1986).

3.1.3.1 Reservoir

Soils in the reservoir have developed on coarse textured fluvial deposits which have formed islands and terraces on land adjacent to the Peace River. Bear Flat (Bear Flat 1 and Bear Flat 2) soils have developed on these fluvial deposits. Alluvial soils occur in the floodplain of the Halfway River and the Moberly River.

Bear Flat 1 soils have sandy loam surface texture over weakly calcareous deep fine sands, 1 to 3 m thick, over channel gravels. Bear Flat 1 soils are well drained, with pH 7.0 to 7.5 at the surface and pH 7.5 to >8 below 25 cm. Vegetation consists of deciduous and conifer forest. Topography is nearly level or gently undulating, often with incised channels.

Bear Flat 2 soils occur on abandoned back channels and cobble and gravel bars often thinly veneered with sand and sandy loam sediments. Due to the recent deposition of material, Bear Flat 2 soils lack distinct horizons. Bear Flat 2 soils are well drained, but often have a high water table and may be subject to annual flooding. The pH is >7.0. Where present, vegetation consists of grasses, forbs, and shrubs.

The alluvial soils are on sandy, silty, loamy, and often gravelly deposits. Soil texture varies, but is generally sandy, and drainage varies. Most alluvial soils are subject to annual flooding.

The soil characteristics in the reservoir area are generally favourable to the preservation of organic archaeological materials, being well-drained, calcareous Bear Flat 1 soils. The deposition of sand to the Bear Flat 1 soils may have protected archaeological sites by covering them. The Bear Flat 2 and alluvial soils are less likely to hold archaeological sites as these fluvial deposits are relatively recent.

3.1.3.2 Dam and Generating Station

The dam, generating station, and surrounding areas include islands in the Peace River, terraces north and south of the river, valley slopes, and uplands north and south of the river. Soils on the islands and terraces adjacent to the river are fluvial deposits with Bear Flat soils (Bear Flat 1, Bear Flat 2) as described above for the reservoir.

The terraces on the north side of the river are fine-textured fans or terraces. The soils, Taylor, have a silty clay texture, are well- to moderately well-drained, with pH 5.8 to 6.4 in the surface horizons and pH 7.5 below 50 cm. The terraces on the south side of the river consist of glacio-fluvial deposits. The soils, Clayhurst, are coarse textured (gravelly sand and sandy loam), rapidly drained, with slightly calcareous subsoil.

The river valley slopes are primarily colluvium derived from fine-textured lacustrine material and moraine material. Soils are generally Regosols with variable texture and variable drainage conditions. Attachie soils are on the slopes north of the river (with south aspect) and Septimus soils are south of the river, with north aspect.

The upland north of the river is mainly fine-textured glacio-lacustrine material. Soils are Falher, with clay loam to clay texture, moderately well drained, with pH 5.1 to 6.5 in the surface 30 cm and calcareous (pH 7.4) and saline lower horizons. The upland south of the river consists of loamy and sandy glacio-fluvial deposits. The sandy areas are Sundance soils, and the loamy areas are Davis soils. Sundance soils have sandy loam texture, are well to rapidly drained, with pH 5.5 at the surface 35 cm and pH 6.0 to 7.6 in the lower horizons. Davis soils have silt loam texture, are well drained, with pH 6.0 at the surface and pH 7.4 to 8.3 in the lower horizons.

Soils in and near the dam sites are well drained and have a pH of 7.5 or greater in the subsoil (below about 25 cm); except Sundance which has pH 6.0. These conditions would be generally favourable to the preservation of archaeological materials. The surface of the Taylor, Clayhurst, Falher, Sundance, and Davis soils ranges from pH 5.1 to pH 6.5, and these lower pH values may have had some adverse effect on organic materials. The Attachie and Septimus soils are difficult to evaluate as they are generally on colluvium on the steep valley slopes.

3.1.3.3 Highway 29 Realignment

The Highway 29 realignments cross several soils, including Branham and Coldstream as well as Clayhurst, Davis, and Taylor which are described above for the dam and generating station.

The Branham soils, on sandy terraced fluvial materials, have sandy loam to silt loam texture, are well-drained, with pH 6.1 at the surface and 7.5 below 15 cm. The Coldstream soils, on fine-textured glacio-fluvial materials, have silty clay textures and are poorly drained, with pH 6.0 at the surface and pH 8.0 below 25 cm.

Organic archaeological materials in the highway realignments would generally not be adversely affected by the soil matrix. The Branham, Coldstream, Clayhurst, Davis, and Taylor are well-drained soils (except Coldstream) with pH 6.0 at the surface and pH 7.5 to 8.0 below about 20 cm; these pH levels are not expected to have caused adverse effects to preservation. The Coldstream soils are poorly drained and may have undergone wetting and drying cycles which may have had some adverse effect on organic archaeological materials.

3.1.3.4 Transmission Line

The transmission line corridor traverses sandy and loamy glacio-fluvial materials, loamy morainal deposits and organic (peat) soil. Sundance soils (sandy glacio-fluvial) and Davis soils (loamy glacio-fluvial) are described above for the dam and generating station.

Beryl soils, developed on clay materials, have silt loam texture at the surface and clay below 25 cm and are moderately well-drained, with pH 5.0 at the surface and pH 7.6 below 25 cm. Moberly soils, developed on loamy morainal deposits, have a gravelly silt loam to loam texture and are moderately well-drained, with pH 5.0 to 6.0 to 65 cm and pH 7.7 in the lower horizons. Lynx soils, developed on loamy glacio-fluvial materials, have silt loam to silty clay loam texture, are well-drained, with pH 5.1 to 25 cm and pH 7.5 in the lower horizons.

The organic (peat) soils are Terric Mesisols and average about 100 cm in depth. Kenzie soils, developed in bog peat, have surface pH 3.6 which increases to pH 5.2 with depth. Eagelsham soils, developed in fen peat, have pH of about 5.0 throughout the profile.

Organic archaeological materials in the corridor would generally not be adversely affected by the soil matrix of the mineral soils. The Beryl, Davis, Lynx, Moberly, and Sundance soils are well-drained soils with pH 5.0 to pH 6.0 at the surface and pH >7.5 below about 25 cm (Sundance pH 5.5 to 6.0). The pH 5.0 to 6.0 may have had some adverse effect on the preservation of organic materials. The Coldstream soils are poorly drained and may have undergone wetting and drying cycles which may have had some adverse effect. The pH of the organic soils Kenzie (pH 3.6 to 5.2) and Eagelsham (pH 5.0) would be expected to have adverse effects on organic materials, However, these organic soils are continuously saturated to the surface (or frozen in winter), which may be favourable to the preservation of organic materials in archaeological “wet sites.”

3.1.4 Hydrology

Within the LAA there are three large drainages. The primary drainage is the Peace River, which drains the Rocky Mountain Trench. The second largest drainage is for the Halfway River, which flows into the Peace River from the northwest at roughly the middle of the LAA. The third largest drainage is the Moberly River, which flows into the Peace River immediately upstream from the dam location.

Archaeological and historical sites in and near the LAA tend to correlate with water sources, not only due to the presence of potable water, but also because of the associated aquatic and terrestrial resources and transportation opportunities afforded by rivers and lakes. The results of the archaeological assessment confirm this pattern, and are supported by traditional land use studies conducted by, or on behalf of, First Nations (see Section 3.2.4, below, and Volume 3 Appendix B First Nations Community Assessment Reports). Known palaeontological sites also tend to occur near watercourse, primarily because they are often exposed by erosion.

3.1.5 Palaeoenvironment

Environmental factors such as glacial advance and retreat, climate, plant and animal resources, and geomorphological changes affect the availability of resources and the suitability of the landscape for human use and occupation. Environmental changes can influence human cultural systems in ways that can be detected archaeologically through changes in site distribution patterns, artifact styles, and other lines of evidence. Due to the potential relationship between changes in the palaeoenvironment and changes in the archaeological record, it is important to consider the effect of palaeoenvironment changes when evaluating archaeological site potential or attempting to understand the archaeological record.

Palaeoenvironmental reconstructions are formed by integrating many different and often dynamic elements of a landscape. Pertinent aspects of ancient environment reconstructions include climate, sea level, geomorphology, geology, and biota, which can provide a better understanding of how landscape changes affect the presence and ranges of flora and fauna critical to human survival. Intersections of past landscapes, environments, and peoples are central to understanding prehistoric cultural changes. The disappearance of Pleistocene megafauna in North America is one example of the widespread effect that human subsistence may have had on the landscape. Such a major biotic fluctuation may have prompted technological or subsistence responses in aspects of prehistoric culture, some of which may be present in the archaeological record. Such manifestations could include changes to projectile point styles or other artifact styles, changes to habitation areas and features on the landscape, or even what parts of the landscape were utilized by people. The following sections describe salient aspects of the palaeoenvironment and potential implications for human populations.

3.1.5.1 Glaciation and Glacial Lakes

The Peace River (including the LAA) lies within the “Ice Free Corridor,” the area of western Canada believed to have been ice free during periods of the late Wisconsian advance and retreat (Catto, et al. 1996). It has been proposed that perhaps the earliest people in North America travelled through the Ice Free Corridor on their way to the rest of North, Central, and South America (Goebel, et al. 2008). Similarly, megafauna such as mammoths and fauna such as bison likely immigrated through the same ephemeral tract of land between the Cordilleran and Laurentide ice sheets (Wilson 1996).

The LAA was heavily glaciated during the Pleistocene. Research by Hartman and Clague (2008) indicates that at least three Laurentide glacial advances occurred from the east and at least one Cordilleran glacial advance occurred from the west. It is plausible that the Cordilleran and Laurentide ice sheets coalesced at least once during this time (Hartman and Clague 2008). The timing of glacial activities interests archaeologists as it indicates whether or not the LAA could have been a possible travel route or habitation area for people.

As the Laurentide ice sheet advanced from the east sometime between 27,400 and 22,020 BP, Glacial Lake Mathews formed behind it. Coarse sediments found near the margins of Glacial Lake Mathews indicate proximity to a glacial front (Hartman and Clague 2008). The sediments from Glacial Lake Mathews have not been dated directly, although they are younger than a mammoth tooth (27,400 BP ±130 14C yr BP; Mathews 1978) and a bison vertebra (26,450 ±310 14C yr BP) found in underlying paleovalley gravels near Taylor (Hartman and Clague 2008).

As the Laurentide ice sheet retreated sometime after 22,000 BP, water levels at Glacial Lake Mathews dropped, and smaller ice-dammed lakes, including Glacial Lake Peace, were formed. The thickness of Glacial Lake Peace deposits shows greater isostatic rebound to the west, indicating that the western region was ice-free for a longer period of time and that the Cordilleran ice sheet retreated from the LAA more rapidly than the Laurentide ice sheet (Hartman and Clague 2008). Menounos, et al. (2009) state that the Cordilleran ice sheet rapidly retreated after its maximum extent at 16,000 BP, as evidenced by isostatic rebound data from Glacial Lake Mathews (Fletcher, et al. 2002; Severin 2004).

Contrary to Menounos, et al.'s (2009) assertion that maximum Cordilleran extent occurred at 16,000 BP, there is evidence to suggest that a second coalescence of Laurentide and Cordilleran ice occurred afterwards between 15,180 and 13,970 BP (Hartman and Clague 2008, Figure 10), although this re-advance is controversial (Mathews 1978; Catto, et al. 1996; Geertsema and Jull 2002; Hartman and Clague 2008) and is not supported by radiocarbon dating.

As the ice sheets retreated for the last time, the resulting glacial lakes drained quickly causing, erosion of the modern Peace River valley which downcut rapidly from 13,970 to 10,500 BP (Catto, et al. 1996; Hartman and Clague 2008). Jull and Geertsema (2006) report radiocarbon dates from charcoal found in a fan at Bear Flat as evidence of forest fire charcoal as early as 16,250 BP, which suggests that Glacial Lake Peace may have retreated earlier than the previously discussed 14,000 BP. Current evidence suggests that the LAA may have been suitable for human habitation as early as 16,000 BP, and certainly by 14,000 BP.

The late glacial and early post-glacial drainage patterns would have been more dynamic than modern drainages. The combined extent of Glacial Lake Mathews and Glacial Lake Peace inundated most of the area near the LAA, except for a small location south of Charlie Lake and between Tea Creek and Fish Creek. If cultural materials were deposited in the LAA prior to 22,000 BP, they almost certainly would now be covered by glacial lake sediment and would be deeply buried.

The earliest dated archaeological evidence from the vicinity of the LAA comes from Charlie Lake Cave, which lies just north of the LAA and is located just above a remnant of a raised beach that probably formed a prolonged shoreline of Glacial Lake Peace (Driver, et al. 1996:266). The oldest cultural component from the site is dated to 10,500 BP, and Driver, et al. (1996) suggest that Glacial Lake Peace had drained from the Fort St. John area by that time based on the presence of a bison bone dated to 10,550 BP recovered from gravels in the Fort St. John area (Apland and Harington 1994). As Glacial Lake Peace retreated from the LAA and the Peace River began to incise into the glacial till, terraces were created that would have been conducive to human habitation.

3.1.5.2 Palaeoclimate

Reconstruction of past climate regimes can be achieved using microfossils and botanical remains such as pollen, fossil midges, molluscs, diatoms, and dinoflagellates. Several pertinent palaeoecological studies (White and Mathewes 1982, 1986; Hebda 1995; Spooner, et al. 2002; Pisaric, et al. 2003; Jull and Geertsema 2006; Clague and Hartman 2008; Fleming 2008; Menounos, et al. 2009) were conducted in the Peace River region and the present understanding is based on these studies. Climate change can be inferred from the regional pollen records and the changes in vegetation they document. For the purpose of this assessment, the focus is on late-glacial and post-glacial climate changes. The generalized Holocene climate of the Peace region is believed to generally follow the trend shown in Figure 3.1).

Hebda (1995) divides the post-glacial Holocene climate in northeastern British Columbia into three general phases spanning the past 9,500 years: The Early Holocene (9,500 to 7,000 BP) warmer and dryer “xerothermic” stage; the Middle Holocene (7,000 to 4,500 BP) warm and moist “mesothermic” stage; and the Late Holocene (4,500 to present) moderate and moist modern conditions. In general, moisture increased from 8,500 to 6,000 BP and temperatures fell from 4,500 to 3,000 BP.

White and Mathewes (1986) conducted pollen analyses and radiometric dating on sediment cores from two lakes in the Saddle Hills, near the LAA. Their results suggest that by 11,700 BP the area was represented by a poplar, willow, sage, and grass zone with pine and spruce trees also present. There appears to be a change to a drier climate and an increase in forest fires from approximately 8,700 to 8,200 BP. This change is also seen in work done by Pisaric, et al. (2001) who record a higher density of charcoal present in ancient pollen and stomata samples from 9,800 to 8,000 BP at their study area north of Fort St. John, suggesting that conditions were drier. White and Mathewes (1986:2315) believe that the subsequent weakening of certain weather patterns associated with the retreating Laurentide ice sheet lengthened the growing season, permitting pine to become more common, peaking around 7,400 BP, while grasslands were absent.

The Saddle Hills data demonstrate that there was no major increase in the area of grassland during the early Holocene warm period, nor was there a major advance and subsequent retreat of the grassland-forest ecotone, meaning that the warmer climate had little influence on the formation or extent of the Peace River grasslands (White and Mathewes 1986: 2316). White and Mathewes (1986) propose that grasslands developed *in situ* from the early post-glacial flora (approximately 11,000 years ago), meaning that the extensive Peace River grasslands originally observed by early Europeans have not changed significantly since the ice sheets retreated. The presence of a stable grassland implies that animals dependent upon grasslands, such as bison, may have been present since deglaciation and could have been available as a food source for people in the Peace River area since the late-Pleistocene.

Research by White and Mathewes (1982) at Fiddler’s Pond (near the LAA) revealed that climatic conditions from 7,250 to 5,500 BP were drier and warmer than at present and somewhat different than the early Holocene. Pollen analyses suggest that the Alberta Plateau in the Peace River region (including the LAA) went through a change in climate after the peak of the Hypsithermal resulting in a switch from upland boreal forest to open grassland (White and Mathewes 1982:564). They also suggest the possibility of greater fire frequency. Around 5,500 BP, moister conditions caused the pond to become permanent, surrounded by wetlands. Modern vegetation was established by 3,100 BP. An increase in fir pollen between 4,000 and 3,000 BP may indicate a cooling in temperature, while an increase in sedge pollen suggests an increase in precipitation (White and Mathewes 1981:565).

White and Mathewes (1981) suggest that the formation of permanent ponds and wetlands around 5,500 BP represents a key shift in the character of the Alberta Plateau. During the early Holocene, many small lakes and ponds and associated well-drained areas may have been suitable places for human habitation, but as the lakes became wetlands and ultimately bogs, settlement patterns may have changed. The climate and vegetation changes would have likely affected ungulate and bird habitats as well. It may be possible that an increase in permanent wetlands allowed for an increase in the local moose population and in certain bird species.

Radiocarbon dating of palaeosols and buried charcoal horizons indicates that fires occurred on a fluvial fan at Bear Flat, within the LAA (Jull and Geertsema 2006). Charcoal evidence for forest fires dates as far back as approximately 13,500 BP, with higher fire frequencies at about 10,000 to 9,000 BP, 8,200 to 7,500 BP, 6,000 to 5,500 BP, and 2,800 to 2,200 BP (Jull and Geertsema 2006:435). While these spikes in forest fire activity may relate to climate and vegetation changes, human influence should not be discounted. Strong, et al. (2009) discuss how spring burning by First Nations in the lower Peace region was common in the past, and that fire was employed for several reasons, such as habitat and settlement improvement. Jull and Geertsema (2006) acknowledge that any or all of the periods of higher fire frequency may have been due to a present human population.

Clague, et al. (2009) note that, in contrast to the prominent shifts in climate during the Pleistocene, the Holocene was once viewed as a time of relatively benign climate change. Geologists, geographers, and botanists are discovering that there may be far more complexity to Holocene climate, vegetation, and glacial activity than previously thought. Clague, et al. (2009) provide evidence that the Little Ice Age (1350 to 1879 A.D.) was complex, with multiple glacier advances separated by intervals of more restricted ice cover (Pielou 1992:308).

This new view of the Holocene includes three tiers of climate complexity: 1) millennial-length periods of glacier expansion; 2) fluctuations of glaciers on time scales of decades and centuries; and 3) glacial activity on very short time scales of a decade or less.

3.1.5.3 Fauna and Megafauna

Changes in past environments would have affected the distribution of wildlife habitat. Megafauna, such as mammoths, and Pleistocene species of bison and muskox existed until the end of the Pleistocene in North America. Numerous bison remains have been documented and radiocarbon dated in the Peace River region (Apland and Harington 1994; Hartman and Clague 2008). Genetic evidence demonstrates that the Pleistocene bison population was in significant decline prior to 30,000 BP, which pre-dates archaeological evidence, and that environmental change at the end of the Pleistocene was largely responsible for the decline of megafauna (Shapiro, et al. 2004).

Shapiro, et al. (2004) investigated the evolution and demographic history of Pleistocene bison via DNA analysis and associated radiocarbon dates from 442 bison fossils. The evidence indicates the presence of two separate bison populations in North America, a northern population that originated in Beringia and gradually moved south as well as an earlier population that was present in Beringia but moved south into central North America prior to the Last Glacial Maximum (sometime before 22,000 BP) and gradually moved north. The movement of both populations was dependent upon the presence of an ice-free corridor. Analysis of the bison remains radiocarbon dated from the 10,700 to 10,000 BP layers from the Charlie Lake Cave site (Driver and Valleriès 2008) demonstrates the presence of both the northern and southern bison populations within the Peace River area by 10,500 BP indicating that an ice-free corridor had been well established by that time. The ice-free corridor allowed for the movement of large animals such as bison as well as people.

3.1.5.4 White River Ash

The White River tephra deposit originated from at least two eruptions of the stratovolcano Mt. Churchill, in the St. Elias Mountains of southeastern Alaska, 25 km west of the Yukon border. These massive explosions deposited an enormous volume of tephra over the region, as thick as 50 cm in places (Bunbury 2008). The first (north lobe) eruption occurred between 1,900 and 1,500 BP and spread tephra northwards along an axis just west of the Alaska – Yukon boundary as far north as the Yukon River (Lerbekmo and Campbell 1969; Hughes, et al. 1972; Lerbekmo, et al. 1975). The second larger (east lobe) eruption occurred at approximately 1,147 BP (a date of 803 A.D.; Clague, et al. 1995) and spread primarily east as far as Yellowknife. The White River tephra deposit covers about 540,000 km^2 and likely extends as far south as Muncho Lake, British Columbia (Robinson 2001), which is about 400 km north of the LAA.

Workman (1979) and Moodie, et al. (1992) suggest that the tephra from the 803 A.D. eruption triggered human population displacements that led to Athapaskan migrations eastward into the Mackenzie Valley and southward into northern British Columbia. Workman (1979) suggests that the environmental devastation wrought by the tephra would have forced people to abandon vast territories, with population displacements that rippled outward from the periphery of the ash fall. Moodie, et al. (1992) and Ives (2003) argue that the two White River events may explain some of the language history in the region. Specifically, Ives (2003:267) stated that the north lobe White River event (ca. 1,900 BP) “corresponds in time with the intermontane and coastal migrations of the Pacific Coast Athapaskans... while the east lobe event corresponds with the divergence of the Canadian and Apachean Athapaskans after about 1,200 BP.”

3.1.6 Modern Vegetation

Biotic variability within the LAA has been closely tied to regional climatic conditions. The distribution of vegetation and plant communities had a major influence on prehistoric travel, settlement, and subsistence patterns. Certain plant communities provided habitat that supported many of the species of animals used by Aboriginal and non-Aboriginal peoples. Many plant species were important sources of food, fuel, and medicine.

The LAA is situated within three different biogeoclimatic zones and various subzones. The majority of the LAA is within the Moist Warm variant of the Boreal Black and White Spruce (BWBSmw1) biogeoclimatic zone. However, portions of the off-site construction material source locations extend into the Moist Very Cold variant of the Engelmann Spruce Sub-alpine Fir (ESSFmv2) biogeoclimatic zone and the Wet Cool variant (ESSFwc2). Portions of the LAA are also situated within the Wet Cool variant of the Sub-Boreal Spruce (SBSwc2) biogeoclimatic zone. A summary of the ecology of each biogeoclimatic zone is provided in the sections below and in Volume 2 Section 13 Vegetation and Ecological Communities.

3.1.6.1 Boreal White and Black Spruce (BWBS)

The Boreal White and Black Spruce (BWBS) biogeoclimatic zone generally occurs in valley-bottom settings covered with mixed white spruce and trembling aspen forests, with higher frequencies of the former on slopes with a north aspect. Black spruce and white spruce dominate the forest cover in older stands, but lodgepole pine is often present in dense, usually even-aged stands often representing forest regeneration following wildfires. Aspen, cottonwood, and birch are present in this zone, characteristically in riparian environments or on relatively well-drained, elevated landforms amidst extensive wetlands. The understory generally consists of alder, willow, Labrador tea, wild rose, and other shrubs, with a ground cover of herbs, grasses, and mosses.

A large portion of the BWBS zone is covered by wetlands (e.g., marsh, muskeg). These wetlands are generally confined to the plateaus surrounding the Peace River valley. Muskeg settings are dominated by sphagnum mosses, sedges, a dense shrubby cover of willows, and scattered black spruce and tamarack trees. Marshes are comprised of bodies of open, shallow water surrounded by reed beds and ephemeral wet meadows (Coupé, et al. 1991; B.C. Ministry of Forests and Range 2008).

Lands that are poorly drained and covered by black spruce and tamarack (i.e., muskeg) are customarily thought to exhibit low archaeological potential. However, where micro-topographic rises occur in muskeg, the vegetation also changes as a result of improved soil drainage conditions. Localized landforms elevated above surrounding wetlands are covered by lodgepole pine, aspen, and large-diameter spruce trees. Where encountered in this region, micro-topographic landscape features are generally considered to have archaeological potential as they are excellent locations for seasonal campsites used for resource procurement activities.

3.1.6.2 Engelmann Spruce Subalpine Fir (ESSF)

The Engelmann Spruce Subalpine Fir (ESSF) biogeoclimatic zone occurs in predominantly mountainous terrain, with steep and rugged slopes, and occasionally on dissected high plateaus. Cold, moist, snowy winter conditions prevail within the ESSF for five to seven months of the year producing snow packs of up to four metres. Winter temperatures averaging below 0° C warm up to temperatures of 10° C for two months during the short and cool summers. Engelmann spruce and Subalpine Fir are the dominant climax tree species within this zone, with the spruce dominating mature stands and fir abundant in the understory; deciduous tree species are uncommon within the ESSF. Potential archaeological site types in the ESSF biogeoclimatic zone include stone artifact scatters representative of temporary or seasonal campsites, trails, culturally modified trees, and ceremonial areas.

In the wetter sub-zonal areas and high elevations of the ESSF subalpine fir is often dominant. In the drier, wind -protected areas, and in areas that have been disturbed by fire, lodgepole pine is a prevailing succession species. The forest continuity of this biogeoclimatic zone is broken by wet meadows, shrub lands, and avalanche tracks. This varied terrain, snowy winters and wet, cool climate influences the wildlife presence. Game animals such as moose, caribou, mule deer, and mountain goat are found throughout the ESSF. In mountainous areas avalanche tracks provide abundant summer habitat for ungulates, as well as grizzly and black bears. Other, smaller fur-bearing animals like marten, fisher, and red-squirrel inhabit the ESSF and were likely procured in pre- and post-contact times for their furs.

The Engelmann Spruce Subalpine Fir Moist Very Cold variant (ESSFmv2) biogeoclimatic zone has a large variety of herbaceous species within moist subalpine meadowlands. Meadowlands occur in level to gently sloping open areas with less wind exposure and have moist soils throughout the growing season. Ground cover within the higher elevation wet areas consists primarily of subalpine heath and a dense covering of mosses. Caribou can be found in the ESSFmv2 year-round, surviving on arboreal lichen in the winter. Moose and elk are typically found in this subzone during the summer, leaving in the winter to escape the deep snowfall. The steep rugged terrain within the ESSFmv2 ecosystem is generally considered to have low archaeological potential. The high elevation plateaus, meadowlands, and terraces that occur within this zone are considered to have moderate to high archaeological potential due to the presence of food resources.

The Engelmann Spruce Subalpine Fir Wet Cool variant (ESSFwc2) biogeoclimatic zone is usually dominated by oval-leaved blueberry, black huckleberry, black gooseberry, thimble berry, devil's club, black twinberry, and white-flowered rhododendron.

Aboriginal resource procurement within this zone was likely dependent on the varied terrain. The distinctive vegetation that occupies the avalanche tracks of this zone provides access to a variety of shrub and herbaceous species used in subsistence and medicinal practices. Locations particularly suited for trapping of smaller fur-bearing animals as well as hunting of larger ungulates can be found throughout this zone, particularly within the avalanche tracks and meadows during the summer months. While many of these subsistence gathering practices leave few archaeological remains, temporary or seasonal camping sites are likely to be found on plateaus and terraces, and within the meadows associated with resource procurement areas. As such, these landforms where present, are considered to contain areas of archaeological potential.

3.1.6.3 Sub-Boreal Spruce (SBS)

The Sub-Boreal Spruce (SBS) biogeoclimatic zone is characterized by severe snowy winters and relatively short warm moist summers. Coniferous forests dominate the landscape, with hybrid white spruce and Subalpine Fir being the climax tree species. The moist climate, rich soils, and heavy precipitation provide a nutrient rich climate for pioneer stands of paper birch (B.C. Ministry of Forests and Range 2008) The SBS biogeoclimatic zone supports the greatest number of moose in British Columbia (Meidinger, et al. 1991:217). These animals are uniquely adapted to survive the severe winters on the gently rolling terrain and abundant wetlands of this subzone. Small mammals able to survive above the snow (e.g., hare) are also located within this subzone and may have provided trapping opportunities in both pre- and post-contact times.

The Sub-Boreal Spruce Wet Cool variant (SBSwc2) has fewer frost-free days than other SBS subzones. The poorly drained abundant wetlands, although generally considered to be of low archaeological potential, provide rich aquatic plant life and attract large mammals. Where present, micro-topographic features, the banks and shores of rivers, creeks, and oxbow lakes are locations that may have been used for temporary campsites.

3.1.7 Modern Wildlife

The Peace River Basin Ecoregion has a diversity of wildlife habitats, ranging from Rocky Mountain foothills in the west and south, to closed-canopy coniferous forests, extensive wetlands, and developed agricultural lands that partly mimic Pre-contact prairie-parkland settings. The frequency of large and small rivers and their tributary streams enhances habitat variability. Species typically observed in mosaics of deciduous forests and agricultural lands include white-tailed deer, mule deer, moose, coyotes, red-tailed and other hawks, and grouse. As indicated in Section 3.2.4 below, many of these species were and still are utilized by Aboriginal people throughout the region. In Pre-contact times, there was a traditional emphasis on resident ungulates such as bison, caribou, deer, and elk. Moose have always been present, but apparently were never as abundant as they are today. Archaeological site types associated with the procurement and use of animal resources include campsites, butchering locations, and hearths.

3.2 Cultural Setting

3.2.1 Pre-contact Period

Pre-contact period archaeological sites are those locations which can be solely attributable to Aboriginal lifeways prior to contact with, or influence from, European traders and explorers. Contact period sites are those sites which demonstrate a mixture of Aboriginal and non-Aboriginal traits or show the influence European establishment and expansion on Aboriginal groups. A glossary of common archaeological terms is provided in Appendix A.

Although archaeological sites represent discrete locations, the material remains that are present in these sites are usually associated with traditional Aboriginal land use practices that took place throughout the surrounding landscape. As such, the boundaries of an archaeological site do not constrain the spatial extent of traditional activities associated with that site. Furthermore, some traditional activities, such as berry gathering, medicinal plant collecting, and spiritual practices, leave little or no archaeological remains and thus are more appropriately addressed by a Traditional Use Study.

Archaeological sites are given a unique identifier according to the Borden Site Designation system used throughout Canada (Borden 1952). This scheme uses latitude and longitude to provide a unique alphanumeric label for archaeological sites. The four alternating upper and lower case letters (e.g., HaRk) designate a unique "Borden unit" measuring 10 minutes of latitude by 10 minutes of longitude. Sites are numbered sequentially within a Borden unit, based (usually) on their date of discovery. For example, HaRk-1 is the first site recorded in the "HaRk" Borden unit, in this case the Farrell Creek Site beside Highway 29, downstream from Hudson's Hope.

3.2.1.1 Archaeological Site Types

Archaeological remains are formed as a consequence of certain kinds of activities taking place over a period of time at a specific location. An archaeological site may be composed of one or more kinds of archaeological remains because several different activities can take place at a single location. Generally speaking, larger sites will tend to exhibit a greater diversity of archaeological remains compared to smaller ones.

Each part of the province exhibits a distinctive suite of archaeological site types particular to that region. Archaeological sites in the Peace region exhibit a mix of characteristics from the Northern Plains (Peck 2011). and Western Subarctic culture areas (Clark 1981, 1991), as well as elements from the Northern Interior (Magne and Matson 2008) . Typical archaeological remains that have been documented or can be expected to occur in this region can be defined as follows:

- **Artifact Scatters:** The most common archaeological remains in this region, artifact scatters are composed of clusters of (usually) stone artifacts, including expedient tools and formed tools and the waste products of tool manufacture and maintenance (debitage). Small artifact scatters or isolated artifact finds occur frequently and may reflect the use of the landscape by highly mobile groups. However, as noted by LeBlanc (2004), the highly mobile inhabitants of the subarctic relied heavily on tools formed from bone, wood, sinew, and other perishable materials, which tend to disintegrate. Recurrently occupied sites will typically cover a larger area and have higher frequencies of cultural materials, possibly including butchered animal bones and fire-altered rocks, as well as charcoal-stained soils.

- **Subsistence Features:** These are usually present at locations traditionally used to harvest and process resources, but are often associated with larger sites as well. Cache or storage pits are the most common type of subsistence feature in other parts of northern British Columbia and appear as roughly circular surface depressions between 1 m and 4 m in diameter, frequently in closely spaced clusters and often in proximity to rivers. However, ethnographic records (e.g., Jenness 1937) suggest that above-ground caches built of logs were common in the Peace region, and such features would rarely leave detectable traces in the archaeological record. Cooking features are another subsistence feature that may be encountered; they may appear as shallow, ash- and charcoal-filled depressions, or level platforms covered with black carbon-stained soil, but would usually be larger than warming hearths. Boiling pits are small, deep, hide-lined pits used for processing animal fat and marrow. Though typically a feature of plains sites, such features are associated with groups who practiced communal hunting and may exist in the Peace region. Archaeologically, these appear as dense concentrations of cracked and degraded cobbles associated with broken animal bones in a distinctive pit.

- **Burial Places:** These are locations where people interred their dead. The term "burial" also refers to above-ground forms of interment. Burial places may occur near places of communal aggregation, or in low densities throughout the traditional landscape for individuals who died when away from habitation sites. Although soil conditions would appear to favour the preservation of ancient ancestral remains within this segment of the Peace River valley, recorded burial places are rare compared to other settings, including elsewhere in the Peace District.

- **Petroforms:** These are deliberate constructions of stones (e.g., walled enclosures, cairns, stone-lined pits), which might be associated with subsistence activities such as hunting blinds or game-drives, or possibly with ceremonial activities.

- **Rock Art**: These are figures or symbols either carved into rock (petroglyphs) or painted on rock (pictographs). Petroglyphs are not recorded from northeastern British Columbia, while pictographs are rare but documented from Stuart and Nation lakes to the west of the Rocky Mountains. Pictographs are typically found on vertical exposures of smooth, fine-grained bedrock, or on very large boulders, along steep shorelines or trails, or locations of strong spiritual significance to Aboriginal people.

- **Culturally Modified Trees:** Trees that have been intentionally altered by Aboriginal people as part of their traditional use of the forest are said to have been "culturally modified." Although several tree species were traditionally used by Aboriginal people, cambium-stripped lodgepole pines are the most common type in northern British Columbia. A cambium-stripped or bark-stripped tree has had a section of bark removed from the trunk, leaving a lenticular bark scar as it heals (BC Archaeology Branch 2001; Prince 2001; Marshall 2002). Most cambium-stripped trees will occur in proximity to major watercourses or along trails or portages, on well-drained, level ground or hillsides with less than 50º of slope, and in old forest stands with mature pine trees (BC Archaeology Branch 2001).

- **Trails**: These are overland routes used to provide access between communities or to resource procurement areas. Many still exist as well-worn paths on the landscape, but the presence of ancient trails may also be inferred by linear distributions of other kinds of archaeological sites. Trails and portages that were used during the fur-trading era in the Peace District likely followed the routes of traditional trails. In the homesteading period of the region, some traditional trails were progressively modified into settlers' wagon roads, and ultimately automobile roads.

- **Historical Sites**: These are Post-contact remains, principally including artifacts, structures, and features associated with Euro-Canadian settlement and land use, although the Aboriginal inhabitants of this region quickly incorporated these things into their material culture as they became available. In the Peace District, early historical sites will be associated with trapping and the fur trade, followed by early 20th century settlement and resource extraction enterprises.

3.2.1.2 Summary of Regional Cultural History

For non-specialist readers, the best summaries of Pre-contact archaeology in northern British Columbia have been prepared by Fladmark (1986) and Clark (1991), while Helgason (1987), Berry and Brink (2004), and Bryan (1991) do the same for Alberta. For academic readers, Wright (1995, 1999) describes the prehistory of the entire country from earliest times to approximately 1,500 years ago. Pokotylo and Mitchell (1998), Richards and Rousseau (1987), and Rousseau (2004) synthesize southern Interior Plateau prehistory. Helmer (1977), Magne and Matson (2008), and Matson and Magne (2007) are some of the few sources that discuss the central Interior Plateau of British Columbia. Peck (2011) and Vickers (1986) summarize the prehistory of the Plains of Alberta, while Ives (1993) covers northeastern Alberta and Clark (1981) describes Western Subarctic prehistory. LeBlanc (2004) proposed a five-period cultural chronology for a portion of the boreal forest of Alberta, drawing on influences from the Plains and the Subarctic. Lastly, Fladmark (2009) provides a summary of his many years of field studies across northern British Columbia, most notably including the Peace District. The following text is derived primarily from these sources.

The Peace District, including the heritage resources LAA, is situated within the Western Subarctic Culture Area according to Clark (1981, 1991). Published archaeological material on the Peace District is rare, but noteworthy research has been conducted at several archaeological sites in the wider region (see Section 5.2.1.4). Substantial site excavations were conducted at the Farrell Creek Site (HaRk-1) in the Peace River valley (Spurling 1980; Valentine, et al. 1980), and detailed testing was done at two other sites (HbRf-40, HbRf-62) located within the dam site (Alexander 1982). In lands adjacent to the heritage resources LAA, important excavations took place at Charlie Lake Cave (HbRf-39) a short distance northwest of Fort St. John (e.g., Driver and Vallières 2008; Driver, et al. 1996; Fladmark 1996; Fladmark, et al. 1988), and more recently at a pair of open-air sites (HbRf-2, HbRf-83) along the Alaska Highway near the Charlie Lake locality (Archer 2009). Aside from the findings of these few sites, the archaeological resources identified during the present study must be interpreted in the context of archaeological investigations that have taken place beyond the heritage resources LAA, in regions to the north, east, and southwest of the Peace District.

Although it will be shown in Section 5.1.1 that nearly a hundred archaeological excavations or other scientific investigations have taken place within the Peace District of British Columbia and neighbouring parts of Alberta, little attempt has been made to develop a detailed sequence of Pre-contact cultures for northeastern British Columbia beyond the synthesis proposed by Howe and Brolly (2008). The following discussion is based on comparable data from the central Interior Plateau of British Columbia to the west and south, the southern Yukon and southwestern Northwest Territories to the north, and the Northern Plains to the southeast. Based on several sources, archaeological cultural sequences developed for surrounding regions are presented in Figure 3.2.

Archaeologists working in different regions of North America typically frame their temporal constructs within a three-fold division of Pre-contact cultures, usually known as the "Early," "Middle" (or Archaic), and "Late" Pre-contact periods. In most of the regions discussed in the following text, the Early Pre-contact period begins around 12,000 years before present (BP) with the initial occupation of newly deglaciated lands at the end of the Wisconsinan Glaciation. The Middle, or Archaic, Pre-contact period begins variably around 7,500 to 7,000 BP, and the Late Pre-contact period begins around 1,500 to 1,200 BP (e.g., Peck 2011). Plains cultural chronologies frequently refer to Early Pre-contact period materials as "Palaeoindian," while temporally overlapping materials from the subarctic and arctic areas are attributable to parallel traditions known as the Palaeo-Arctic and the Northern Cordilleran traditions. In contrast to pronounced regionalism evident during later Pre-contact periods, the Palaeoindian, Palaeo-Arctic, and Northern Cordilleran traditions are reflective of people who collectively occupied the entire North American continent, from the Bering Sea to the Gulf of Mexico, and from the Atlantic Ocean to the Pacific in relative homogeneity (e.g., Madsen 2004; Meltzer 2009).

3.2.1.2.1 Early Pre-contact Period (12,000 to 7,500 BP)

The Palaeoindian Tradition

Palaeo-environmental studies indicate that portions of the Peace region were suitable for human habitation around the time of the Pleistocene–Holocene transition. Dated archaeological sites of any kind earlier than 7,500 BP are scarce everywhere in British Columbia, but a significant number of dated Early Pre-contact sites are known from Alberta and Saskatchewan (Gryba 2001; Peck 2011; Vickers 1986). A notable exception from the Peace District is Charlie Lake Cave (HbRf-39) near Fort St. John, the earlier occupations of which are associated with an early Palaeoindian projectile point and butchered bison bones, radiocarbon-dated between 10,770 ± 120 and 9,990 ± 150 BP (Driver, et al. 1996; Fladmark, et al. 1988). Though investigated over 20 years ago, this remains the oldest unambiguously dated archaeological site in British Columbia.

The earliest archaeological sites across North America represent cultural complexes characterized by tools and weaponry associated with hunting extinct mega-fauna such as mammoth and bison, although smaller species are also represented at many sites. The most characteristic artifacts of the Palaeoindian tradition are a temporal sequence of distinctive lanceolate and stemmed projectile point styles, each used to arm spears and lances or atlatl darts. Many other Early Pre-contact tools, such as choppers and scrapers, are indistinguishable from later varieties. Early Pre-contact period artifacts, made of bone, ivory, or wood, have been recorded from different regions of North America, but have not yet been identified from the Peace District.

While the earliest groups are known to have hunted big game (Meltzer 2009), including extinct species of bison (*Bison antiquus* and *Bison occidentalis*), Pleistocene horse, mammoth, and mastodon, all of which were contemporaries, these classic Pleistocene mega-fauna were nearly all extinct or at least in severe decline by about 10,000 BP (Vickers 1986; Dyke 2005). Later Palaeoindian hunters adapted to hunting smaller ungulate prey (e.g., modern bison, caribou, bighorn sheep) for the last several thousand years of the Early Pre-contact period.

Figure 3.3 graphically portrays one version of Palaeoindian cultural complexes and corresponding time periods on the Northern Plains of North America (Pettipas 2011). Figure 3.4 illustrates idealized types of Palaeoindian projectile points reported from northern Alberta and northeastern British Columbia (Vickers 1986; Peck 2011). These artifacts denote different technological approaches to tool-manufacture, especially in regards to the

means of hafting projectiles to spear- or dart-shafts. As shown in Figure 3.3, more than one point style was in use at a time, and Pettipas (2011) has promoted the concept of "co-traditions" of different populations residing in the same region, manufacturing different styles of tools and pursuing identical or at least similar ways of life.

Figure 3.5 diagrams Pettipas' (2011) model of Palaeoindian co-traditions on the Plains. Beginning with a fluted point series (Vickers 1986) contemporaneous with a hypothesized willow-leaf point series, the former produces a fluted Folsom offshoot (as well as other styles in the eastern and southeastern United States), but evolves more directly into a "broad concave-based lanceolate co-tradition" (Pettipas 2011). The willow-leaf points evolve directly into a series of variably lanceolate point forms in the "slender leaf-shaped lanceolate co-tradition" (Pettipas 2011). A "stemmed or shouldered co-tradition" develops as a later offshoot of the slender lanceolate co-tradition (Pettipas 2011). Lastly, there appears to be another, "western stemmed-point co-tradition" in North America (Beck and Jones 2010), evidence for which is present in southern British Columbia (e.g., Stryd and Rousseau 1996). The following text presents the Palaeoindian complexes in the conventional sense, as shown in Figure 3.3, but references their relationships within Pettipas' (2011) co-tradition concept.

- **Clovis (11,050 to 10,800 BP):** Clovis points are associated with the oldest securely dated archaeological sites in North America, though there is increasing evidence that similarly aged or even older sites are present. Of generally large, lanceolate form, the outstanding feature of Clovis projectile points is an overshot flaking technique and the removal of channel flakes that form "flutes" on one or both faces of the artifact. On Clovis points, the flute-scars are usually no longer than about half the total length of the blade (Wormington 1964; Kooyman 2000). There is usually evidence for smoothing or grinding of the basal margins. Clovis and Clovis-like point styles are found throughout the American Southwest, Rocky Mountains, Plains, and Midwest, but only rarely on the Pacific Slope (Beck and Jones 2012). In Canada, typical examples of Clovis points are reported from Nova Scotia to Alberta, including one specimen from the Smoky River, a tributary of the Peace River (Vickers 1986). Another very distinctive aspect of the Clovis complex is use of a blade-and-core technology to create macroblades from prepared cores. Recently, a cache of several obsidian macroblade cores has been recovered from Williston Reservoir and claimed as evidence for a Clovis presence in the Rocky Mountain Trench (Millennia 2008).

- **Charlie Lake – Goshen – Basally-Thinned Triangular (11,000 – 10,300 BP):** These are names used by different authorities (e.g., Vickers 1986; Frison 1991; Gryba 2001; Peck 2011) to describe the same style of Palaeoindian projectile point, which in all its variants remains part of the "broad concave-based lanceolate co-tradition" (Pettipas 2011). This point type (or types) is intermediate in age between Clovis and Folsom and coeval with both (Frison 1991; *cf.*, Peck 2011). The general shape of these points is reminiscent of Clovis points, but with one or more small, basal-thinning scars being present on one or both faces of the artifact rather than a flute scar (Frison 1991). In Canada, many of these points are distinctly smaller than Clovis points, including the specimen from Charlie Lake Cave and one from Smoky River, Alberta (Gryba 2001), as well as examples recently found in the Finlay Reach of Williston Reservoir (e.g., Arcas 2007). Others are closer in general size and configuration to a typical Goshen point, including another specimen from Williston Reservoir (Arcas 2003). This point style is more abundant in western Canada than either Clovis or Folsom, with several examples reported from the Peace District, as well as from Saskatchewan and Alberta (Fladmark 1981; Wilson 1989; Gryba 2001; Peck 2011). Furthermore, several points of this type have been found in sites from central and northern Alaska (Clark and Clark 1983).

- **Folsom (10,900 to 10,200 BP):** Folsom points are younger than Clovis points in every site where the two styles are found together (Frison 1991), and represent an offshoot from the "broad concave-based lanceolate co-tradition" (Pettipas 2011). They are named for a site in Folsom, New Mexico, which marked the first indisputable discovery of ancient human artifacts in association with extinct Pleistocene fauna in the New World (Wormington 1964). Folsom points are smaller and lighter than Clovis points, and the flute scar occupies nearly the entire face of the artifact—normally, both faces are fluted. Most Folsom points exhibit fine marginal retouch, as well as basal edge-grinding. Folsom points have not been reported from any site in British Columbia (*cf*., Peck 2011), and are relatively rare in Alberta and Saskatchewan too, but specimens are reported from the Grande Prairie area (Vickers 1986; Peck 2011) and could be present in the Peace District of British Columbia as well.

- **Agate Basin – Hell Gap (10,500 to 9,750 BP):** Agate Basin represents the oldest projectile points (Wormington 1964) in the "slender leaf-shaped lanceolate co-tradition" (Pettipas 2011). All Agate Basin points are long and slender, with straight or slightly convex margins and no evidence of a stem at the base. Many of these points have a thick, biconvex cross-section, but some are as thin and lenticular as the other kinds of points described here (Frison 1991). They may have slightly convex or straight bases, and there is usually evidence of lateral edge-grinding (Wormington 1964). Where Agate Basin and fluted points occur in the same sites, the former tend to be in a younger context, although radiocarbon dates for some Agate Basin sites are contemporaneous or older than the youngest fluted point sites (Vickers 1986). Agate Basin points—or points resembling them—are fairly abundant in western Canada, including the Peace District and Williston Reservoir (e.g., Arcas 2003, 2007; Millennia 2010). The Agate Basin complex produced an evolutionary offshoot, the Hell Gap complex, which commences the "stemmed – shouldered co-tradition" (Pettipas 2011). Hell Gap points are known from southern Alberta (Vickers 1986), but also from Williston Reservoir (Arcas 2003; Millennia 2008). Unlike Agate Basin points, Hell Gap points exhibit pronounced tapering towards their base, with their widest part three-quarters of the way to the tip (Frison 1991).

- **Alberta – Scottsbluff – Cody (9,800 to 8,500 BP):** This complex of related artifacts is an evolutionary development of Hell Gap in the "stemmed – shouldered co-tradition" (Pettipas 2011). The characteristic artifacts are regarded as being related because they are often found together in sites of the same age, and all exhibit a characteristic well-formed stem at the base (Frison 1991). Scottsbluff points are distinctly lanceolate, with slightly shouldered stems exhibiting considerable edge-grinding. Eden points are a variant of conventional Scottsbluff points, but are very narrow with thick, biconvex cross-sections. Alberta points are consistently larger than Scottsbluff points and have very pronounced stems; curiously, they sometimes have tips that have been deliberately blunted (Wormington 1964). Cody knives are fairly rare, stemmed knives with one straight and one oblique margin (see Figure 3.4). Artifacts of the Alberta – Scottsbluff – Cody complex are quite common from Alberta and Saskatchewan to Wyoming and the Plains states (Peck 2011). Although mainly associated with plains environments, they are also found in mountain and subarctic sites and appear to be the commonest Early Pre-contact period artifacts in the Peace District and Williston Reservoir (Arcas 2003; Fladmark 1981; Millennia 2008, 2010; Vickers 1986; Wilson 1989).

- **Late Palaeoindian Complexes (8,500 to 7,500 BP):** This interval represents a transitional period between typical Palaeoindian cultures and succeeding Archaic cultures of the Middle Prehistoric period (Peck 2011). A variety of regional projectile point styles and complexes appear, possibly denoting local cultural developments responding to local conditions. Thus, in Alberta, there is an interrelated series of Frederick (also known as Jimmy Allen) – Lusk points that represents the terminal development associated of the

"broad concave-based lanceolate co-tradition" (Vickers 1986; Peck 2011). The Frederick – Lusk point types are both lanceolate forms with somewhat convex margins and straight or slightly concave bases, and a distinctive pattern of parallel-oblique flaking (Vickers 1986). Projectile points in the Frederick – Lusk style are reported from Williston Reservoir (Millennia 2008), and by extension, could occur in the Peace District as well. Directly evolving from the Agate Basin complex within the "slender leaf-shaped lanceolate co-tradition" is the Foothills – Mountain complex (Frison 1991), in Alberta more generally known as the Plains – Mountain complex (Reeves 1983; Vickers 1986; Peck 2011). Plains Mountain projectile points maintain the Agate Basin tradition of elongate, lanceolate points (Angostura type), together with weakly stemmed (Pryor Stemmed type) and shouldered points (Lovell Constricted type) (Frison 1991; Pettipas 2011). In northeastern British Columbia, typical examples of all Plains – Mountain point styles are found throughout the region, including Williston Reservoir (Arcas 2003; Millennia 2008, 2010), where there is a risk of confusion with older Agate Basin points.

The Palaeo-Arctic Tradition – Northern Cordilleran Tradition

The "Palaeo-Arctic tradition" denotes the earliest inhabitants of far northwestern Canada and Alaska, though the same manifestations have been given other names by different authorities (e.g., Clark 2001; Heffner 2002). The people of this tradition shared their technology, if not their culture, with communities living in Siberia, and many archaeologists refer to this single, interrelated region as "Beringia" (West 1996). Coeval with the Palaeo-Arctic tradition, and possibly slightly earlier in time, sites attributable to a different cultural tradition are also known from the northern Yukon Territory and neighbouring parts of eastern and central Alaska. This tradition exhibits important differences from the Palaeo-Arctic culture, and has been called the "Northern Cordilleran" tradition by Clark (2001).

Archaeological components characteristic of the Palaeo-Arctic tradition differ principally from their Northern Cordilleran contemporaries in that the stone toolkit is dominated by three classes of artifacts, including large, leaf-shaped projectile points, burins, and most important, a microlithic core-and-blade technology (Figure 3.6). Microblades are small, straight-sided blades of stone driven from a specially prepared core. They differ from macroblades, which have already been discussed in association with the Clovis complex, in their size, with microblades typically being less than 5 to 7 mm in width. Burins are specialized stone tools used to engrave bone.

Northern Cordilleran components apparently do not possess microblade technology, and their projectile points generally resemble later Palaeoindian types, with an emphasis on lanceolate and leaf-shaped or bipointed styles (Millar 1981; Hare, et al. 2008).

Definitive sites attributable to the Palaeo-Arctic tradition are known from central and northern Alaska (West 1996), but Heffner (2002) describes a characteristic "Beringian" site from west-central Yukon, and Clark (1983, 2001; also Millar 1981) identifies a Palaeo-Arctic component at Fisherman Lake, near the Liard River in southwestern Northwest Territory. At a site (FlRq-13) in Prince George, British Columbia, a distinctive artifact assemblage dominated by large leaf-shaped to lanceolate projectile points, without associated microblades, was dated between 7,970 and 8,770 BP (Burford, et al. 2008). Although the excavators referred FlRq-13 to the Old Cordilleran culture of the Pacific Northwest (Burford, et al. 2008), the dates and artifact assemblage from this site would also appear to fit a Northern Cordilleran attribution.

The presence of Palaeo-Arctic or Northern Cordilleran archaeological sites in the Peace District is debatable. Although large, leaf-shaped projectile points and microblades have been recovered in some abundance from Williston Reservoir in the Rocky Mountain Trench (Arcas 2003, 2007; Millennia 2008, 2010), leaf-shaped points appear to be absent or at least rare in the Peace District. However, evidence of microblade technology dating to 9,000 BP was discovered during the investigations at Charlie Lake Cave (Driver, et al. 1996; Fladmark 2009), and during the Simon Fraser University investigations for the Site C Project (Alexander 1982). More recently, archaeological excavations along the Alaska Highway near Charlie Lake found abundant microblades and cores in association with both lanceolate (presumably Early Pre-contact) and side-notched (probably Archaic) projectile points (Archer 2009). Unfortunately, radiocarbon dates from the excavated sites were not informative about the antiquity of the microblade-bearing component (Archer 2009a).

3.2.1.2.2 Middle (7,500 to 1,500 BP) and Late Pre-contact Periods (1,500 BP to Contact)

The Palaeoindian, Palaeo-Arctic, and Northern Cordilleran cultures collectively spanned the entire North American continent for approximately 4,500 years. After 7,500 BP, the succeeding Middle Pre-contact populations that replaced them adopted technologies that emphasized a more pronounced regional focus.

The Middle Pre-contact period throughout most of North America, but especially east of the Rocky Mountains, commences between about 8,000 and 7,500 BP with the Archaic period in its many regional variants. For northwestern North America, potentially including the Peace District, the “Northern Archaic” complex has been proposed (Esdale 2008).

The appearance of Archaic cultures marks a shift to a more generalized pattern of subsistence (Peck 2011). Larger and more diverse toolkits characterize Archaic period sites. Archaic projectile points are dominated by notched forms, which reflect a different style of attaching the point to a dart-shaft, which was hurled at prey animals with the aid of a throwing-stick or “atlatl” (Hare, et al. 2012). Fladmark (2009) has asserted that most microblade-bearing artifact assemblages found in the Peace District will be attributable to the Archaic period, although they are present as early as 9,000 BP at Charlie Lake Cave and hence possibly also representative of the Palaeo-Arctic tradition.

On the Northern Plains in Alberta, the Late Pre-contact period follows the Middle Pre-contact period at 1,350 BP (Peck 2011), and is correlated with a significant technological shift to use of the bow-and-arrow, with correspondingly smaller projectile points.

In northwestern Canada, the east lobe eruption of White River Ash took place at approximately 1,250 BP (Lerbekmo 2008). The volcanic ash covered northern British Columbia, the southern half of Yukon and much of western Northwest Territories, and appears to have stimulated an outward migration of resident Athapaskan groups (e.g., Ives 1993, 2003, 2006, 2010), some of which eventually found their way to the southern Interior Plateau of British Columbia, the Southern Plains of Alberta, the American Southwest, and isolated communities on the Pacific Coast of Oregon and California.

The Northern Plains Cultural Sequence

The "Northern Plains" as discussed here includes southern and central Alberta, traditionally at least as far north as Edmonton, but commonly pushed into the Peace District of British Columbia as well (e.g., Spurling and Ball 1981). Of all cultural areas adjacent to the heritage resources LAA, the Northern Plains has the best-reported and most clearly defined archaeological sequence. Figure 3.2 shows two versions of the Plains cultural sequence, and Figure 3.7 portrays the projectile point styles that distinguish the Middle to Late periods of the sequence.

In older sources (e.g., Vickers 1986), the earliest widespread Middle Pre-contact period culture on the Northern Plains is the Mummy Cave complex, with characteristically large, side-notched projectile points, followed by the Oxbow Phase (Reeves 1983; Vickers 1986). In these models, the Mummy Cave complex originated around 7,500 BP and persisted until about 4,500 BP. More recent research in Alberta and neighbouring regions has unveiled a considerably more diverse picture, which Peck (2011) splits into five successive complexes (Country Hills, Mummy Cave, Maple Leaf, Calderwood, Estevan), all of which are characterized by large corner-notched or side-notched points.

According to Peck (2011), the Oxbow Phase lasted from 4,500 to 4,100 BP and appears to represent an evolutionary development of the Estevan complex. Oxbow is typified by small, side-notched points with concave bases and excurvate blade margins. Compared to the complexes that formerly comprised the Mummy Cave complex, the Oxbow culture is considerably more widespread throughout the Northern Plains and may be present in the LAA at the Farrell Creek Site (HaRk-1) (Spurling 1980) and at other sites in northern British Columbia and Alberta as well (Spurling and Ball 1981; Ives 1993). Projectile points exhibiting stylistic similarities to Oxbow points occur on the southern Interior Plateau of British Columbia, but these specimens are at least 600 years younger than the last appearance of the Oxbow Phase in Alberta (Rousseau 2008); comparable specimens do not appear to be present in the central Interior Plateau (Magne and Matson 2008). Recently, several examples of large, lanceolate points with deeply concave bases and the characteristic rounded "ears" of Oxbow projectile points have been found in the Williston Reservoir area (Arcas 2007; Millennia 2010). It has been asserted that these artifacts represent a lanceolate form of Oxbow point (Millennia 2010), but based on other metric attributes (Green 2005), these specimens may denote an Archaic period cultural complex unique to the Rocky Mountain Trench.

Before Oxbow had disappeared from the Plains, the McKean complex appeared, characterized by the McKean and succeeding Hanna – Duncan point styles that are quite distinct from either Mummy Cave or Oxbow complexes (Vickers 1986; Webster 2009), and may represent a separate development originating elsewhere on the Central or Southern Plains. As shown in Figure 3.7, the McKean and Hanna – Duncan point types are distinct from each other, but intergrades between the types occur (Fromhold 1972). Projectile points resembling all styles of the McKean complex have been discovered in the Peace District (Spurling 1980), and versions also occur in slightly younger contexts on the central and southern Interior Plateau of British Columbia (Magne and Matson 2008; Rousseau 2008).

The McKean complex is succeeded in time by the Pelican Lake complex, dating between 3,600 and 2,800 BP, and distinguished by corner-notched projectile points (Vickers 1986; Peck 2011). Pelican Lake is then followed by a series of short-lived complexes believed to originate from different parts of the Plains, and ending the Middle Prehistoric period with the Besant complex (2,100 to 1,500 BP) with small to medium-sized, stemmed or side-notched points (Vickers 1986; Peck 2011).

An intervening Sonota complex marks a transitional period between the Middle Prehistoric Besant complex and the Late Prehistoric Avonlea complex (Vickers 1986; Peck 2011), which is only found in southern Alberta and further east on the Northern Plains. The Avonlea complex, typified by small, finely made points with small side-notches, appears to mark the introduction of bow-and-arrow technology to this region. Avonlea points are distinctive, widespread, and tend to be prolific where they occur, but have not been reported from the Peace District to date (e.g., Howe and Brolly 2008).

The Avonlea complex is followed in time by three late side-notched point complexes (Highwood, Old Women's, One Gun), which were also used to arm arrows. The Old Women's and One Gun side-notched points are successively younger than the Highwood complex (Peck 2011), and were still in use by the Aboriginal inhabitants of Alberta when the first contacts with European explorers and traders occurred.

The Cultural Sequence from the Northern Interior – Western Subarctic

For the purposes of this report, the "Northern Interior" includes:

- That part of northern British Columbia that lies within the Arctic drainage, west of the Rocky Mountains
- Parts of British Columbia within the Pacific drainage, *north* of the Skeena and Nass Rivers
- The southern Yukon and southwestern Northwest Territory, within the Pacific and Arctic drainages

This corresponds to much of the western Subarctic Culture Area as defined by Clark (1981).

After approximately 7,000 BP, the Palaeo-Arctic and Northern Cordilleran traditions were replaced by cultures that merged elements of both and are not particularly easy to distinguish from their predecessors. Clark (1981, 1991) provides a summary of this very large, complex region. Other syntheses of northern Interior prehistory also appear in site reports for the region (e.g., Workman 1978; Millar 1981; Gotthardt 1990; Hare 1995; Clark and Gotthardt 1999; Heffner 2002). Magne and Matson (2008) focus specifically upon the sequence of projectile points found in northern British Columbia.

Figure 3.8 illustrates some characteristic artifacts from the Northern Interior, but may include some attributable to the Early Pre-contact period as well. Figure 3.2 presents two archaeological sequences for this region, based on the research of Millar (1981) and Workman (1978), with some refinements added by later investigators. The sequences are somewhat misleading because, compared to the preceding discussion of Northern Plains prehistory, the Northern Interior cultural sequence is documented from relatively few, widely scattered archaeological sites, and little is known about the regional scope of the archaeological periods that are named. These cautions aside, the Northern Interior culture history can be summarized as follows. Around 7,000 BP, Palaeo-Arctic and Northern Cordilleran complexes dominated by microblades and lanceolate or leaf-shaped projectile points persisted throughout the region (Heffner 2002; Hare, et al. 2008). Many of the projectile points are stylistically similar to Palaeoindian types such as Agate Basin (Clark 2001).

The persistence of stone tool technology is exemplified by the Late Pre-contact Taltheilei complex, which appears to have originated around 2,600 BP and survived with few technical improvements until the first explorations by European fur-traders (Clark 1991; Wright 1999). The Taltheilei complex can be considered as an

eastern expression of the same archaeological complex called the Taye Lake Phase in southwestern Yukon (Workman 1978; Wright 1999). Both archaeological complexes are believed to have been created by the direct ancestors of the Athapaskan-speaking peoples who resided in those regions at Contact, at which time the Taltheilei complex was found from northern Alberta to the Arctic Ocean and Hudson Bay (Clark 1991; Wright 1999). The origins of the Taltheilei complex are uncertain; the earliest known sites were found in the barren grounds of Nunavut and around Great Bear Lake (Clark 1987), but a site with asserted Taltheilei affiliations was excavated on the Peace River near Grand Prairie (Bryan and Conaty 1975; *cf*., Donohue 1976), and Wright (1999) has suggested that Taltheilei originated in northern British Columbia.

Early Taltheilei-style projectile points superficially resemble points associated with the latest Palaeoindian complexes (LeBlanc 2004), though the latter would usually exhibit a higher degree of craftsmanship as well as the basal edge-grinding that characterizes most Early Prehistoric projectile points. Later Taltheilei points included medium-sized and small side-notched varieties, similar to Late Prehistoric projectile points found at Fisherman Lake (Millar 1981), southwestern Yukon (Workman 1978), and elsewhere (Clark 1981, 1987; Wright 1999).

As time progressed, other new artifact types were adopted by inhabitants of the Northern Interior, including typical Archaic-style projectile points with large side- or corner-notches (see Figure 3.8). One example of this is found at the Annie Lake Site in southwestern Yukon (Greer 1993; Hare 1995). The Annie Lake point is a small, thin point with a deeply concave base. It has been compared with McKean points from the Plains and with Shuswap horizon points from the southern Interior Plateau of British Columbia (Greer 1993), but is dated to the period between 5,100 to 4,600 BP—considerably older than comparable Plateau and Plains types. A notable feature of later Middle Pre-contact period projectile points in this region is a trend to very broad side-notches with incurvate margins (e.g., Figure 3.8:q-s).

Recent studies (Farnell, et al. 2004; Andrews and MacKay 2012) on alpine ice patches in the mountains of southeastern Alaska, the Yukon, and the Northwest Territories have shed light on many aspects of prehistoric technology seldom preserved in archaeological sites. The ancient inhabitants of this region actively procured game in these environments, where caribou and bighorn sheep sought summer forage in a setting free of insect pests. In receding ice-patches, archaeologists have discovered spears, bows and throwing sticks, atlatl darts and arrows (some still fletched) with attached projectile points, together with other artifacts such as snares and traps, all of which have been radiometrically dated (Hare, et al. 2004, 2012; Alix, et al. 2012; Andrews, et al. 2012; VanderHoek, et al. 2012).

Atlatl darts from the southwestern Yukon ice patches, with radiocarbon dates ranging from 8,360 to 1,260 BP, were typically armed with stone projectile points, though bone and antler dart points were also found (Hare, et al. 2012). Some darts were of composite construction, and several points were hafted to short foreshafts. In contrast, bows and arrows were dated after 1,180 BP, and where projectile points were attached, all were made of bone or antler (Hare, et al. 2012). From four ice-patches in the Selwyn Mountains of the Northwest Territories, four arrows were dated between 850 and 270 BP, two of which were armed with notched projectile points made of stone (Alix, et al. 2012).

The Cultural Sequence from the Central Interior Plateau of British Columbia

The Central Interior Plateau is defined as that part of British Columbia lying within the Pacific drainage, including the middle part of the Fraser River basin south to approximately Quesnel, as well as the Bulkley – Skeena River system as far west as Hazelton.

In the past, archaeologists tended to look southwards (e.g., Donahue 1975; Carlson 1998) or eastwards (e.g., Magne and Matson 2008) for comparisons to archaeological assemblages from this region. James Helmer (1977) published an early iteration of central Interior Plateau cultural history in which he observed that archaeological remains from this region more closely resembled those from sites in northern British Columbia and the southern Yukon (the "Northern Interior" as described previously), a conclusion also made by others (e.g., Clark 1981). Magne and Matson (2008) find strong similarities between Middle Pre-contact projectile point styles from the Northern Plains and those recovered from sites in the central Interior Plateau.

Magne and Matson (2008) expand on earlier work on the Chilcotin Plateau of British Columbia (Matson and Magne 2007) to distinguish between Late Pre-contact, triangular side-notched arrow points made by Interior Salishan and Athapaskan-speaking communities in the same region (Figure 3.8). Points made by Athapaskan peoples are found to be more elongated, with wide, shallow side-notches and concave, sometimes spurred bases. The Salishan versions have the shape of an equilateral triangle, with deep and narrow notches (sometimes multiple notches) and a straight basal margin (Magne and Matson 2008). A similarly characteristic, and perhaps more widespread, artifact associated with a Late Pre-contact Athapaskan presence is the Kavik point (Figure 3.8), which is a small arrow point with a distinctive contracting stem (Matson and Magne 2007).

Although only a few sites have been investigated compared to neighbouring regions, there is a general understanding that ancient peoples of the central Interior Plateau were highly dependent upon salmon runs for subsistence, supplemented by game (especially deer, elk, and moose) and plant foods to a greater extent than the Northern Interior region.

Howe and Brolly (2008) have proposed a projectile point sequence for northeast British Columbia that draws on various influences from the surrounding culture areas described above, in which the prevalent influences during of the Early Pre-contact period in the LAA are drawn from the widespread Palaeoindian traditions found across North America, such as Clovis, Goshen, Agate Basin, and later Plano cultures. They propose a strong Plains influence during the Middle Pre-contact period with increasing influence from the Western Subarctic from the north during the Late Pre-contact period.

3.2.2 Ethnographic and Ethnohistorical Summary

This section draws upon the available ethnographic and ethnohistorical evidence relating to the Aboriginal peoples occupying and using northeastern British Columbia, to help interpret the archaeological record. The section relies upon written descriptions of Aboriginal groups prior to the 20th century and does not include oral history information, which was compiled separately in "living memory" traditional land use summaries (TLUS) prepared by, and for, participating First Nations (see Volume 3 Section 19 Current Use of Lands and Resources for Traditional Purposes for a summary of TLUS results).

The first ethnohistorical information of Aboriginal peoples using and occupying northeastern British Columbia is found in the journals of early explorers and traders Alexander Mackenzie (1927, 1970) and Simon Fraser (1960), and later in the observations of Daniel Harmon of the North West Company (Harmon 2006), who was sent to New Caledonia in 1810 to take charge of the company's post first at Stuart Lake and then at Fraser Lake. Also relevant are the accounts of Daniel Gordon, who in 1879 accompanied George Mercer Dawson as secretary of an expedition to explore the Peace River and Pine River passes as possible routes for the Pacific railway (Gordon 1880), and the accounts of Samuel Black (1824), Paul Leland Haworth (1917), and adventurer William Francis Butler (1903).

Two early and significant ethnographic sources include the works of Father A.G. Morice (1890, 1895, 1905, 1928), an Oblate missionary who gathered information about the Dakelh (Carrier) and Tse Keh Nay (Sekani) in the 1890s, and anthropologist and linguist Pliny Earle Goddard, who conducted ethnographic and linguistic studies among the Beaver Indians (Dane-Zaa) in the Peace River and Hay River regions in 1913 (Goddard 1916). Goddard was followed by anthropologists Diamond Jenness (1937), who published an ethnography of the Sekani, and John Honigmann (1946), who studied the Fort Nelson Slavey (Dene Tha) people in 1943.

Anthropologists Michael Asch (1981, 1995), Glenda Denniston (1981), and Honigmann (1981) have published summaries of Slavey, Sekani, and contemporary Métis societies. Since the 1960s anthropologist Robin Ridington has written extensively about the Dane-Zaa and continues to work with them (Ridington 1968, 1979, 1981, 1982, 1990, 1994, and 1995). The University of British Columbia, Special Collections Library houses his field notes and texts (Ridington 1965–1972). In 1981, Ridington (1981:359) noted that little had been written about the Dane-Zaa prior to the commencement of his documentation.

Also relevant are the observations of anthropologist Hugh Brody, who in the 1970s conducted a landmark study of Aboriginal land use and occupancy in northeastern British Columbia, as well as the aboriginal land use mapping work of natural resource scientist Martin Weinstein (1980). Brody (1988) referred to the geographic complexity and resource diversity of the northeastern corner of British Columbia.

Archaeological evidence supports a presence of Aboriginal peoples in the northeast corner of what is now British Columbia, dating back thousands of years. Evidence from Charlie Lake Cave, near Fort St. John, dates to c.10,500 BP, but it is assumed that Aboriginal people were living in the area for some time before this (Fladmark, et al. 1988; Driver, et al. 1996; Driver 1999).

Based on the ethnographic record, the Dane-Zaa and Tse Keh Nay have the longest history of use and occupation of the region. According to Jenness (1937:6–7), "not many centuries ago the Sekani and Beaver were one people divided into many bands which differed but little in language and customs." North West Company fur trader Daniel Harmon (2006:115) observed:

> "They call themselves Sicannies. . .but it is supposed that formerly they belonged and were part of the Beaver Indian Tribe–who on some quarrel separated themselves from their Countrymen by leaving their lands to come higher up River & who are now as I am informed a pretty numerous Clan or Tribe."

Harmon (2006:116) later notes that the "Sicannies" "dialect differs little from that spoken by the Beaver Indians."

Father A.G. Morice (1895:11) explained that in his documentation he identified the "Beaver Indians as a separate tribe" from that of the "Tsé'kéhne" in order "to conform to the long established custom of the traders [e.g., journal years 1808 to 1810 in Harmon 2006:115] and missionaries." According to Morice, from a "philological [linguistic] standpoint, the Beavers. . .are genuine Tsé'kéhne" (Morice 1895:11). The languages of both the Beaver and Sekani "form a recognized geographical subdivision of the Athapaskan language family,

usually referred to as Northern Athapaskan" (Krauss and Golla 1981:67). Cree arrived from further east at the beginning of the fur trade era in the mid- to late-19th century and settled into the Lower and Middle Peace River areas of the traditional Dane-Zaa lands (Ridington 1981:350).

Sites along the Peace River valley were used and occupied by these groups because of the abundance of summer foods and the large wildlife populations. Aboriginal peoples who use and occupy the Peace River region today include Dane-Zaa, Tse Keh Nay, and Cree, along with groups that identify as Métis people, and members of other First Nations.

Given that the focus of this section is to inform the archaeological component of this report, the following discussion focuses on the Dane-Zaa and Tse Keh Nay socio-cultural practices and land use due to their longer history of occupation of the region. However, it is recognized that the Cree and other Aboriginal groups that inhabited the area during the early fur trade may also have left archaeological remains. The archaeological assessment does not attempt to assign cultural affiliations to specific sites.

Dane-Zaa "Real People" (Beaver Indians, Tsattine)

According to Ridington (1981:351–352, 1982:472, 1995:239) the people designated in some sources as "Beaver Indians" or Tsattine ("dwellers among the beaver"), identify themselves as Dane-Zaa ("real people"), in their Athapaskan (Dene) language. Ridington observes that lands they once used and occupied included land adjacent to the Peace River extending from the Peace River Canyon to Lake Athabasca. It was a region that included a varied habitat and supported rich resources of game and fur-bearing animals. Large areas adjacent to the Peace River were either natural prairies or kept as parkland and prairie habitat by intentional burning. Intentional burning allowed the Dane-Zaa to maintain large areas in subclimax vegetation without the labour-intensive activities normally associated with agriculture and animal husbandry.

Traditionally, the Dane-Zaa lived in bands[1] of 25 to 35 people in the prairie, forest, and muskeg country along the Peace River between the Rocky Mountains and Lake Athabasca. Group size was managed in response to resource availability. The territory they used included several different biomes and, therefore, varied resources were available to them. Bands moved seasonally from place to place, at times covering as much as 400 km during the course of a year. Territories were not held individually, but the group had definite territorial rights. In the summer and fall, times of abundance, related bands came together for ceremonial and social activities. In times of scarcity people split up into smaller groups, making them less vulnerable to starvation (Ridington 1981:351–352, 1982:472, 1995:239).

Diet

For the Dane-Zaa, hunting was more significant than gathering or fishing, with the bulk of their food coming from the meat of large animals (Ugarenko 1979:47–48; Ridington 1981:350–351, 1995:239). Their semi-nomadic lifestyle was dependent upon the movement of the animals they relied upon for food, clothing, and shelter.

[1] The term "band" is used in the anthropological sense and should not be confused with the 1876 *Indian Act* definition of band.

Big game animals (e.g., moose (*Alces alces)*, wood bison (*Bison bison athabascae)*, and elk (*Cervus canadensis*) were important to the Dane-Zaa, with moose being the most significant source of food, clothing, and shelter (Gordon 1880:174; Butler 1903:125; Goddard 1916:215; Jenness 1932:383; Ridington 1981:351–352, 1982:472, 1995:239, 1979:48–56). Goddard (1916:215) noted that the preferred habitat of the moose is swamps and large tracts of timber (i.e., areas rich in aspen-poplar, willow, and birch), in particular along streams and on the islands. In spring and summer, moose are primarily aquatic feeders and can be found within the forest along the shorelines of ponds, lakes, and rivers. In autumn and winter, moose eat the twigs, bark, and saplings of aspen, poplar, birch, and willow. At that time of year their movements are more restricted and they tend to gather in sheltered locations (Ugarenko 1979:49–50).

As stated earlier, the Dane-Zaa also consumed elk, which grazed in open meadows in spring and summer and ranged along the forest edge in the winter (Ugarenko 1979:50–51). Woodland caribou (*Rangifer tarandus caribou)* were important where available. This animal could be found in the lichen-rich spruce and jackpine forests (Ugarenko 1979:21). Wood bison were found in certain sections of their territory and were a source of food until their decline in the 19th century.[2] They could be found in the open parkland in spring and summer, and in autumn moved to the sheltered parkland-forest transition zone (Ugarenko 1979:49). Jenness (1932:383) observes that the Dane-Zaa drove buffalo (wood bison) into "pounds after the manner of the plains' tribes."

In addition to large game, smaller animals such as beavers (*Castor Canadensis)*, rabbits (*Lepus americanus)*, porcupines (*Erethizon dorsatum)*, and whistlers (marmots) (*Marmota caligata)* were a source of food. Fish, including whitefish (*Prosopium williamsoni*), jackfish (northern pike) (*Esox Lucius),* Dolly Varden trout (*Salvelinus malma malma*), and grayling (*Thymallus arcticus*), provided a source of food at times when big game was scarce (Ridington 1982:472). Goddard (1916:216) stated that fishing took place at the lakes in the "south and east of the Peace River."

During the spring and fall migration periods, grouse (*Canachites Canadensis)*, ducks (*Anas Platyrhynchos*), geese (*Branta Canadensis)*, and swans (*Cygnus buccinators*) were hunted. The Dane-Zaa also gathered goose and duck eggs when the birds nested during the spring (Butler 1903:125; Ugarenko 1979:57).

Although the Dane-Zaa people were primarily a hunting society, plant foods played an important role in maintaining the health and nutrition of its members. They used plants for food and medicine. Butler (1903:210) described what he referred to as "the dessert of a Peace River feast," which included bear fat mixed with saskatoon berries (*Amelanchier alnifolia)* (found on the shores of the Peace River), and powdered moose meat. Other plants gathered along streams included strawberries (*Fragaria vesca*), raspberries (*Rubus idaeus)*, chokecherries (*Prunus virginiana)*, and a few roots. Berries were dried in the sun and stored for winter use (Ugarenko 1979:56). The inner bark of certain trees was also consumed, and the Dane-Zaa also relied on trees for the construction of shelter, in transportation, and as fuel (Goddard 1916:213; Ugarenko 1979:56).

Key Technology

Ridington (1979:66) observed that "[t]raditionally, when their primary objective was procuring food, drives and surrounds (co-operative communal hunts in which many people closed in on an animal whose location was

2 In the early 1800s, the historic range of wood bison included northern Alberta, southwestern Northwest Territories, northeastern British Columbia, and a small section of northwestern Saskatchewan. After 1860, the species is said to have rapidly declined to a population count of 250. The last wood bison is recorded as being shot near Fort St. John in 1906. The North West Mounted Police began to form patrols to protect the animal, and wood bison populations began to recover. Between 1925 and 1928, 6,000 plains bison were barged into the Wood Buffalo National Park, the former range of the wood bison. The plains bison hybridized with the wood bison. In 1971, plains bison were accidentally introduced to Pink Mountain, the former range of wood bison (BC Ministry of Water, Land and Air Protection 2012).

known to them) had been important harvesting techniques. Snares were used even for big game animals." Ridington (1979:69) notes that "traditional subsistence techniques such as snare-hunting, surrounds and drives required very simple material artifacts." Instead, the success of the hunt required "accurate application of complex strategic knowledge" (Ridington 1979:69–70).

Thus, prior to the introduction of firearms, large game animals were hunted with snares, spears, and the bow and arrow. Bows were made of willow and arrows of birch. Arrowheads had blades of flint, and on occasion some were made of moose horn, which hardens with age. Before the introduction of iron, knives were made of moose horn as well as beaver-teeth (Goddard 1916:219; Jenness 1932:384). Goddard (1916:210) was of the opinion that the Dane-Zaa on the Peace River, although not in direct contact with Europeans until approximately 1786, experienced the indirect impact of fur traders for some years prior. In 1793, Mackenzie (1927:260–261), who wintered near Peace River Crossing, observed that when traders arrived on the banks of the Peace River in 1786, the "natives employed bows and snares, but at present [i.e., 1793] very little use is made of the former, and the latter are no longer known."

Moose are a relatively solitary animal and they were most effectively stalked by one or two hunters, with deep snow without a surface crust presenting ideal conditions for stalking the animal. Use of bow and arrow required a hunter to approach within a short distance of the animal. In other instances, moose were driven, with the aid of dogs, into strategically placed snares and during rutting season lured by hunters imitating the call of a bull-moose (Ugarenko 1979:53–55).

Wood bison could be hunted individually or co-operatively. Leonard Ugarenko (1979:52–54) observed that there are no ethnohistorical references to any ceremonial aspects of bison hunting similar to those found among the Aboriginal groups on the Plains. He notes that horses were brought in when bison were on the decline and that prior to the introduction of horses, all hunting took place on foot. This lack of mobility would have made it difficult to encircle and drive large herds of bison. However, in winter bison could have been hunted by one or two individuals wearing snowshoes. The bison would be pursued until they floundered in deep snow.

When fishing, the Dane-Zaa used a bone hook attached to a line of babiche (rawhide). Fishnets were also constructed from babiche. In some instances, fish were caught using stone weirs with platforms of poles below, upon which the fish became stranded (Jenness 1932:383–384).

Jenness (1932:382–384) noted that Dane-Zaa cooking vessels were likely constructed of spruce bark or woven spruce roots, although at the time of his observations (i.e., 1932) they used vessels made of birch bark. Large square bags made of skin were used to store and transport food and small objects (Goddard 1916:213). Skilled at treating hides, the Dane-Zaa were able to pack all their possessions into bags made of moose or caribou skin, either solid or netted from babiche.

Transportation

In summer, canoes, constructed of either birch bark or spruce bark, were used for water travel (Goddard 1916:212; Jenness 1932:382–384). Birch was preferred as it was considered more durable than spruce. Mackenzie in 1793 observed that the "Beaver Indians" made canoes of the bark of birch trees, with the bark taken off the tree the whole length of the intended canoe. Goddard (1916:212) noted in 1913 that horses had been introduced "rather recently." Thus, beginning in the 20th century, horses provided the hunters with greater mobility and enabled them to carry more equipment (Ridington 1995:240). Previously, in summer, goods

were transported overland packed on the backs of dogs or carried by the people themselves. In winter, toboggans constructed of "two thin boards bent in a curve at the front and fastened together by crossbars attached to the upper side," were used (Goddard 1916:213).

Site Locations

The Dane-Zaa economy required a significant degree of mobility. Camps were situated close to feeding grounds of large animals, moving in pursuit of hunting opportunities, or at locations where vegetable foods and fish were seasonally abundant (Ugarenko 1979:59–62). Favoured winter campsite locations were in the forest, sheltered from prevailing winds and with a supply of firewood. Ugarenko suggested that areas within protected river valleys along the tributaries of the Peace River may have been preferred. Moose, elk, and wood bison would have also sought these places as well as the aspen-parkland for winter food. Bluffs and terraces may have also been sought for camp sites. The availability of fresh water would not have been a determining factor, as snow melted over a fire would have sufficed. Winter camps were small, varying in size from two to six lodges.

Summer camps were larger and more permanent than winter camps (Ugarenko 1979:59–62). In summer, plants were abundant in certain locations, and waterfowl and fish had predictable nesting and spawning habits. Drying berries for pemmican and drying and smoking fish confined the Dane-Zaa to a location until the activities were complete. Summer camps were likely located in more open locations, to minimize exposure to insects, as well as close to a source of fresh water and firewood (Ugarenko 1979:60–61).

Dwellings

Besides meat, moose and caribou provided skins for clothing and, in the 19th century, covers for tepees. In 1913 Goddard (1916:210) observed that the "ordinary dwelling" of the Dane-Zaa was a "tipi of the general Northern or Chipewyan type." The cover of the tipi was of skins of caribou or moose. The tipi had a three-pole foundation and, because suitable poles were readily available, they were normally not moved from place to place but left standing. Goddard (1916:210) observed that "[o]ld camp grounds are marked by these poles which in sheltered situations stand for several years."

In the dry summer months the Dane-Zaa also used temporary shelters of brush roughly constructed in the same form, or simple lean-tos (Jenness 1983:383). Winter lodges of logs covered with moss and sod were also constructed (Ridington 1981:352).

Burial Practices

Goddard (1916:222) observed in 1913 that there was evidence that the "Beaver formerly disposed of the dead by placing them in trees or on platforms." Prior to being placed in the trees, the bodies of the deceased were rolled up in birch bark. He also noted that at the time of his visit, families used aerial graves for children and had adopted the practice of burying the deceased underground and erecting a small house over the grave (1916:222). Jenness (1932:384) also observed that Dane-Zaa "deposited their dead in trees or on platforms." On some occasions the body of the deceased would be place on the ground and a small log house was built over the body.

Tse Keh Nay (Sekani, Sicannies, Thecannie, Tse Keh Nay, Tse'Khene)

The Aboriginal people who used and occupied the basins of the Parsnip and Finlay rivers, and the valley of the Peace as far down as the modern town of Peace River, have in the ethnohistorical and ethnographic record been identified by a number of designations (i.e., Bawcanne, Big Men of McLeod Lake, Chief's Band, Meadow Indians, Pouce Coupe's Band, Rocky Mountain Indians, Sekani, Sékanais, Sicannies, Thecannie) (Jenness 1932; Denniston 1981). The Crown has used variations of the names or the more modern designation Sekani.[3] The self-designated term is Tse Keh Nay (Sims 2010).

According to Jenness (1932) and Denniston (1981), towards the end of the 18th century and at the beginning of the 19th century, as the Dane Zaa and Cree moved into the area, the Tse Keh Nay moved westward, occupying the territory around Bear Lake and the northern end of Takla Lake and establishing a village on Tachick River close to the Carrier (Dakelh) of Stuart Lake. To the south, they used and occupied the territory around the junction of the Fraser and Willow Rivers, but appear to have been driven north by the Dakelh and Shuswap (Secwepemc). The establishment of trading posts at Fort McLeod on McLeod Lake in 1805, and at Fort Connolly on Bear Lake in 1826, affected their further expansion. The Omineca gold rush brought both prospectors and miners into Tse Keh Nay territory. After the prospectors left, small-scale mining operations continued (Jenness 1932; Denniston 1981; Littlefield, et al. 2007). In the 1960s, the Bennett Dam was constructed, which resulted in the inundation of land in the Tse Keh Nay territory. The dam, which is located 19 km west of Hudson's Hope, flooded over 1,700 km^2 of river valleys and created Williston Reservoir where trap lines and key forest resource gathering areas were once located (Royal B.C. Museum 2002; Golder 2009a).

Diet

The Tse Keh Nay were primarily hunters, depending on big game such as caribou (*Rangifer tarandus caribou*), elk (*Cervus Canadensis*), moose (*Alces alces)*, black bears (*Ursus americanus)*, mountain sheep (*Ovis canadensis*), mountain goats (*Oreamnos Americanus*), and wood bison (*Bison bison athabascae)* for their subsistence (Morice 1890:130; Haworth 1917:70–71; Jenness 1937; Denniston 1981:433–441). Haworth (1917:71) noted that bears were killed in midwinter when they were hibernating in holes and caves. Denniston (1981:436) explained that "[a]t least in the late eighteenth and early nineteenth centuries, bison, elk, and moose were hunted in the foothills and prairies east of the Rockies by at least some Sekani." Morice (1895:106), when describing the names of the twelve lunar months in "TSÉ'KÉHNE," noted their word for the lunar month of midsummer is "Hə' ke-ta" and means "the buffalo [wood bison] ruts." Smaller animals such as beavers (*Castor Canadensis)*, porcupines (*Erethizon dorsatum)*, hares *Lepus americanus)*, and groundhogs (*Marmota monax*) were also hunted. Tse Keh Nay hunted in both winter and summer.

Jenness (1937:2) described the Tse Keh Nay winter and summer seasonal round as he observed in the 1920s, explaining that they generally spent the period from November until midsummer on the plateau and mountain slopes, running down caribou and moose on the snow. Then, when the snow melted, the Tse Keh Nay would hunt the animals by driving them into snares.[4] They also trapped groundhogs at this time. During the summer

[3] The spelling of "Sekani" was adopted at the turn of the century and accepted by anthropologists.

4 Bengt Anell describes in a text entitled *Running Down and Driving of Game in North America* (Anell 1969:107) methods that various Aboriginal groups in North America used to run down and drive game, including the "Sekani." Anell observes that "[s]nare corrals have a predominantly northerly distribution, and are found. . .among most of the North Athabascans (. . .Sekani. . .)." He explains that the "snare corral differs from other types of pounds in that its wall contains a large number of openings in which snares hang down, often in several rows one behind the other."

months they moved to the lakes or visited other Aboriginal groups (Jenness 1937:1–2).The Tse Keh Nay also ate grouse (*Canachites Canadensis)*, ducks (Anas Platyrhynchos), and geese (*Branta Canadensis)*, (Jenness 1937:1–2). Jenness noted they would fish "only when driven by sheer necessity" (1932:379). When required, they did fish the many rivers, creeks and lakes in their territory for whitefish (*Prosopium williamsoni*), suckers (*Catostomus macrocheilus or Catostomus catostomus)*, Dolly Varden (*Salvelinus malma malma*), and trout. Fish were most abundant in the summer months when the water was high with snow melt.

The Tse Keh Nay used plants for food, medicine, and technology (Bedard 1992; Littlefield, et al. 2007:58). Drawing upon Selwyn (1875:138) who travelled in their traditional territory in the 1870s, archaeologist Beth Bedard wrote (1992:9):

> "Calypso Borealis grew abundantly in the wood areas and their roots were eaten by the natives. Fireweed was eaten, the inside of the stalk would be scraped by thumb and the pith removed. The petioles of Cow parsnip leaves would be peeled and eaten, this was called Indian rhubarb. The cambium layer of the Aspen was used as a food source as well. . ."

In addition, the Tse Keh Nay gathered blueberries (*Vaccinium myrtilloides*) and saskatoon berries (*Amelanchier alnifolia)* along the river banks and in burnt areas, consuming the berries raw, not dried and mixed with grease after the manner of the Carrier and coast tribes. Trees were significant for constructing shelter, as modes of transportation, as fuel, and as a medium for communication. When Haworth (1917:121–122) passed through Fort Grahame he observed the people there were "able to communicate certain ideas, such as where a party has gone or whether it has killed game, by signs scrawled on blazed trees or stakes." Haworth (1917:121) noted that as he and his crew passed through the area they observed "many of these signals along the river."

Key Technology

Much like other hunting and gathering peoples, the Tse Keh Nay developed their hunting technology and methods over many generations. This hunting technology was linked to the resources in their territory and highly specialized for the specific game they sought. As was the case with most Athapaskan groups the Tse Keh Nay used wood, bone, horn, and antler more regularly than stone (Jenness 1932:379; Denniston 1981:436). Their only stone implements were spear- and arrow-points, adze blades, and sometimes knives, with beaver teeth often used for knives instead of stone. They used the same weapons in hunting as in war, namely the bow and arrow, clubs made from the jawbone of a moose, and spears which were fitted with a toggle head for beaver-hunting (Jenness 1932:379–380). Morice (1895:58) noted that the regular hunting or war bow of the Tse Keh Nay was made of mountain maple and five feet and a half or more in length. The edges were smoothed over to permit strips of sinew to be twisted around to strengthen the bow. The pieces of sinew were fastened with "glue obtained from sturgeon."

When Mackenzie (1970:290) travelled to the region he observed that the Tse Keh Nay were "furnished with iron in a manner that I could not have supposed, and plainly proved to me that their communication with those, who communicate with the inhabitants of the sea coast, cannot be very difficult, and from their ample provision of iron weapons, the means of procuring it must be of a more distant original than I had at first conjectured."

Deadfalls snares and nets were of primary importance used to hunt all animals, moose and marmot alike (Jenness 1932:379–380, 1937:39; Denniston 1981:436). Mackenzie (1970:290–291) observed that they "have snares made of green skin which they cut to the size of sturgeon twine, and twist a certain number of them

together; and though when competed they do not exceed the thickness of a cod-line, their strength is sufficient to hold a moose deer: they are from one and a half to two fathoms in length." Each of these snares was specifically designed for each of the species. For hunting caribou, for example, 40 to 50 snares were set in a line through the passes of mountains most frequented by roaming herds of the animals (Morice 1895:101).

Beavers were hunted in spring and summer using a castoreum lure. Morice (1895:66) describes a "beaver-medicine-recipient, or castoreum bottle" made out of a caribou horn and often adorned. The hunter would keep the castoreum in a bottle until required. In winter beavers were trapped in babiche nets set in holes cut into the ice near the beaver lodge (Morice 1895:66).

Tse Keh Nay fishing technology included three-pronged leisters with bone points for spearing fish at night from their canoes and with the aid of jackpine torches. In winter the Tse Keh Nay dug holes through the ice with chisels of moose or caribou antler mounted on long wooden handles. They then used the three-pronged leisters to stab the fish or long gaffs to hook the fish (Jenness 1932:379, 1937:38). They also used fishing nets, which they constructed of nettle fibres or willow roots. These nets were used in both summer and winter, during which time the nets were set under the ice (Jenness 1937:42). In some instances they constructed weirs of brush near beaver-dams, broke the dams, and collected the stranded fish as the water receded (Jenness 1932:379).

Cooking vessels were constructed of spruce bark or woven spruce roots, and bags were made of hide or babiche netting. According to Jenness (1937:35) the Tse Keh Nay had four methods of cooking meat and fish: "boiling in spruce-bark (later birch-bark) baskets over a slow fire; boiling in similar baskets, or in baskets woven from spruce roots, both means of hot stones; roasting on spits; and drying in the smoke of a fire." Food that was not consumed and could not be carried was cached in trees. Once they had access to axes, food was cached in trees on specially built platforms. The bark was peeled from the trunks of the trees to deter wolverines (Jenness 1932:379). Morice (1895:197) observed that:

> ". . .when they happen to be blessed with an abundance of dried meat and wish to preserve it for future use they erect sorts of scaffoldings immediately against the trunk of a tall tree. . . . These consist of two long heavy sticks crossed and firmly bound to the trunk of the tree at their point of intersection, while their ends are secured to some stout overhanging branch by means of strong ropes. Rough boards or split sticks are then laid across this frame which form a floor over which the meat or any other eatable is deposited, carefully wrapped over with skins or spruce bark."

Bedard (1992:9) noted that hides were prepared using "discoidal flaked stone scrapers inserted into a notched stick, as well as with bone scrapers and fleshers." Jenness (1937:35) elaborates, stating that moose hides were cleaned using "either a caribou antler, chisel-ended and with serrated edge, or the shoulder-bone of a moose sharpened like a draw-knife."

Transportation

Tse Keh Nay territory was rugged and densely forested, and therefore rivers were principal transportation routes. For travel in the summer, canoes made of spruce bark were used along major rivers and in other spots for crossing streams. In the winter the Tse Keh Nay carried all their possessions on their backs. Snowshoes were vital for winter and early spring travel and hunting (Jenness 1937:42; Denniston 1981:437).

Bedard (1992:10) observed that the "McLeod Lake Tsek'ehne village" is situated at the juncture of three well-travelled routes in use from the "early historic and probably prehistoric time period." These routes include:

- Carp Lake – McLeod Lake trail
- Summit Lake – Tudyah Lake water route
- Pine Pass – McLeod Lake trail (where the current highway runs)

Dwellings

The Tse Keh Nay did not have permanent villages. Instead, they constructed conical lodges of poles which they covered with spruce-bark, or in some instances constructed "lean-tos" overlaid with bark, skins, or brush. Morice (1895:192–193) observed that among the "Tsé'kéhne," both summer and winter habitations were conical. More specifically, four long poles with forking extremities were set up one against the other, with the lower ends forming a square, of varying dimensions, on the ground. Additional poles were then set up in a circle, with the tops of each resting on the point of intersection of the first four poles. In winter, fascines of spruce and moose skins were laid upon the poles. In summer the poles would be covered with either blankets or skins. Also in summer, instead of conical tents, lean-tos served as shelter (Denniston 1981:437). In both summer and winter, the fire was set in the centre of the structure.

Burials

Fur trader Daniel William Harmon (2006:132–133, 143), writing in the early 19th century, observed among the "sicanny" the cremation of a body, at the conclusion of which the ashes of the deceased were gathered into a box, which was then placed under a shed erected for that purpose in the centre of the village. Father Morice (1928:83), in an article entitled "The Fur Trader in Anthropology: And a Few Related Questions," disputed Harmon's claims, stating that the "Sékanais as a tribe did not practise cremation." He asserted that he had spent enough time with the "Sékanais" and "Carriers" "to be sure of this" and that he has observed with his "own eyes some of the scaffoldings on which the former's dead rested" (Harmon 1928:70). Morice wrote of revisiting the "Sékanais" in 1927 and asking them whether they cremated their dead. He was informed that the "Sékanais never burned their dead, but hid them up in the branches of trees or on scaffolds, when they did not pull down on their remains the shelter in which they had breathed their last" (Morice 1928:84).

During his time among the "Sekani" at Fort McLeod in 1924, Jenness (1937:59) noted that the "present inhabitants at Fort McLeod seem not to recollect the earlier practice of burial in the ground, but have a clear remembrance of cremation." Jenness reports that after the cremation was complete, the remains were wrapped in spruce bark and buried in sandy ground, near an old campsite or on familiar hunting territory.

Jenness (1937:59) noted that after cremation was discontinued, the "Sekani revived an old custom, probably never entirely abandoned, of covering the dead man with the brush hut that sheltered him during his last days and then deserting the locality for a period." Morice (1890:146) and Jenness (1937:59) both noted that prominent individuals would be placed in a coffin hollowed out of a spruce tree and their remains suspended on the forks formed by the branches of two contiguous trees. In other instances the remains of the deceased "were closed up in a standing position in a hollow trunk of a large tree while in its natural state" (Morice 1890:146).

3.2.3 Historical Background

A detailed history of the LAA is beyond the scope of this report, but several aspects of regional history are well documented (e.g., Ormsby 1958; Bowes 1963; Fisher 1977; Roy 1989; Barman 1991; Francis 2000; Fumoleau 2003; Gray 2005). The following text provides a general summary of the history of the LAA.

The first direct European contacts with Sekani and Beaver communities occurred during the last two decades of the 18th Century, when fur trade explorers, including Peter Pond, Alexander Mackenzie, John Finlay, and Simon Fraser entered the area (Denniston 1981). European contact with the Cree of the Churchill and Saskatchewan River basins had taken place years earlier, during the initial westward expansion of Hudson's Bay Company and North West Company traders (Smith 1981). As a result of these contacts, and the prominent role that Cree peoples and language assumed throughout the fur trade era, there was a general westward expansion of the Cree peoples through the 18th and 19th centuries. In many cases, this expansion was accompanied by hostilities between Cree and Athapaskan-speaking groups and by a westward displacement of groups who were not established as fur trade middlemen (Ray 1987).

The expansion of Cree- and Beaver-speaking peoples into the region in the late 18th Century was followed by the arrival of Saulteau-speaking peoples and by an emergent Métis population on the western prairies and eastern slopes of the Rocky Mountains. The oral histories of the Saulteau First Nations point towards an arrival in the area sometime in the late 1800s, following a long migration of Saulteau peoples from southern Manitoba, northwest across the plains in search of a location (Moberly Lake) that had been seen in a vision by a respected elder. The Kelly Lake Métis Settlement, located south of Dawson Creek, was established around 1910 (Andrews 1985).

Alexander Mackenzie passed through the Rocky Mountains via the Peace River Canyon in 1793. Rocky Mountain Fort was established at the junction of the Peace and Moberly Rivers in 1794, and the first recorded non-Aboriginal excursion through the Pine Pass to the south was by a party of deserters from Simon Fraser's expedition of 1806 (Burley, et al. 1996; Helm 2001). Mackenzie's writings record encounters with "Rocky Mountain Indians" (likely Sekani) in the vicinity of present day Hudson's Hope (Denniston 1981:440; Innis 2001:202).

MacKenzie described the region's herds of bison, elk, and moose as a "stall yard" (cited in Burley, et al. 1996). In the early years of the fur trade, these herds provided First Nations and Métis hunters with meat that was the critical food source for the fur traders as well as their own communities. The bison disappeared from the western Prairies in the 1870s, a decade that was also marked by an outbreak of smallpox that may have claimed 75% of First Nations populations and 50% of the Métis in the region (Jamieson 1953).

The 1860s and 1870s saw a brief flurry of gold mining on the banks of the Parsnip and Peace Rivers (Bowes 1963:12; Leonard 2000). However, returns were meagre and the "rush" was soon over. Later, miners on their way to the Klondike gold rush in 1897 to 1899 also passed through the LAA. Some conflicts between the prospectors and First Nations' inhabitants are recorded (Bury 1963:219; Maurice 1963:203; Leonard 2000). Upon completion of the White Pass & Yukon Railway, which eased access to the Yukon from the Pacific Coast, the number of "Klondikers" in the area diminished. Nevertheless, the experiences of the gold rush era generated the impetus for a treaty to be negotiated between the Federal Government, First Nations, and Métis, which ultimately resulted in Treaty No. 8 (Madill 1986:9, 10, 11, 44).

The earliest attempts at agriculture were made by the inhabitants of the trading posts near the river in the mid-1800s, and expanded through the early 1900s, in part due to favourable descriptions of a "wonderfully rich agricultural frontier" (e.g., Brody 1988). Fine, fertile sediments deposited by Glacial Lake Peace have made portions of the region, particularly the lands surrounding Dawson Creek, the most northern agricultural region in British Columbia (Huck and Whiteway 1998). Following the signing of Treaty No. 8 in the late 1800s and again in the 1900s (Leonard 2000), nearly all of the LAA became available for settlement, although the agricultural lands of the eastern half of the Peace River region were most favoured by settlers. Between 1911 and 1921, the population of the Peace region is reported to have expanded ten-fold as settlers began to acquire the fertile, inexpensive and readily available land (Brody 1988).

In the early 1900s, coal claims near Hudson's Hope were being staked. By the 1940s, there were four active coal mines in the vicinity of Hudson's Hope, including the King Gething Coal Mine near Portage Mountain (Maurice 1947:93; Leitch 1950; Kyllo 2003:55-56, 93-95).

Large underground reserves of oil and gas were predicted in northeastern British Columbia and adjoining Alberta by the early 1900s (Gould 1976; McKenzie-Brown, et al. 1993). By the 1920s, the presence of oil was confirmed in the region, although not a single producing well had been drilled, a situation that persisted until 1948, when exploration companies "struck oil," and gas and oil wells began to produce (McKenzie-Brown, et al. 1993). However, it was not until the 1970s that significant, long-term production of oil and gas began in northeastern British Columbia (Brody 1988).

3.2.4 Summary of Traditional Land Use

As mentioned above, several Aboriginal groups prepared "living memory" traditional land use summaries (TLUS) for the Project. TLUS reports for the Blueberry First Nations (Kennedy 2011), Doig River, Prophet River, West Moberly and Halfway River First Nations (Candler and The Firelight Group Research Cooperative with the Treaty 8 Tribal Association 2011), Horse Lake First Nation (Kennedy and Bouchard 2012a), Duncan's First Nation (Kennedy and Bouchard 2012b), Dene Tha' First Nation (Dene Tha' First Nation Lands and Environment Department 2012), and Saulteau First Nations (Nesoo Watchie Resource Management Ltd. 2011) were reviewed for site-specific information that might indicate archaeological site potential. The following discussion draws on those reports to highlight some potential correlations between traditional use information and heritage resources. Specific attention was paid to references to habitation or resource camp sites, burial places, and important cultural sites. The intent of the review is to identify locations that have been noted by First Nations as important subsistence or cultural areas, to inform the interpretation of archaeological sites found at those locations.

3.2.4.1 Camp Sites and Resource Areas

According to the Blueberry River First Nations TLUS (Kennedy 2011), camps established along the Peace River were used as a base for a variety of hunting, fishing, and gathering activities. Bear Flat and the mouth of Cache Creek (east side) are widely discussed as former and current camping locations, and a former winter camp was reported to be at the Attachie school location.

The Doig River, Prophet River, West Moberly, and Halfway River First Nations also reported permanent campsites in the Bear Flat – Cache Creek area, where winter ungulate range and preferred fishing and hunting spots were valued (Candler and The Firelight Group Research Collective with the Treaty 8 Tribal Association 2011). Wildlife corridors, river crossings, and habitat for grizzly bears, moose, deer, elk, and wolves were specifically mentioned. Trails, and springs offering fresh water, were also noted in this area.

Summer camps for making moose hides, drying meat, scraping hides, and collecting berries were located up the Halfway River. Camps were also established at Farrell Creek and Dry Creek for fishing and for hunting moose, deer, elk, and sheep, and near Hudson's Hope for berry picking, fishing, and for moose, deer, and sheep hunting. The Wilder Creek area was used for bird hunting and was a source for chokecherries.

Other important camping and hunting locations include the mouth of the Moberly River, Lynx Creek (which was valued for important wildlife habitat, hunting, and fishing), Hudson's Hope (camping and fishing), Farrell Creek, and the Del Rio area (moose hunting). The south-facing slopes along the Peace River were also identified as a source of rare medicinal plants that are difficult to find elsewhere.

Maps from the combined Doig River, Prophet River, Moberly Lake, and Halfway River First Nations TLUS shows prominent use at the mouths of the Moberly River, Cache Creek (Bear Flat), Halfway River, Lynx Creek, Farrell Creek, and at Hudson's Hope, with extensive use at other localities as well. The maps identify fishing and hunting, short-term and permanent habitations, and gathering places among other cultural uses at these localities.

The Blueberry River First Nations TLUS (Kennedy 2011) states that at least some of the forested islands of the Peace form a sacred refuge for animals, especially moose and deer during calving or rearing. Subsistence hunting is culturally restricted in those locations.

3.2.4.2 Burial Places

Several burial places were mentioned during the TLUS interviews, although specific locations were not reported in most cases. In general, burials were reported to be near the Peace River and major tributaries, and either on the river bank or on hillsides nearby. The Blueberry River First Nations TLUS indicates that hilltops were preferred grave locations and that people would generally be buried near the camp or village where they died.

At least one burial was reported on the south side of the Peace River, associated with "the Fort" (it is unclear which fort the interviewer is referencing). According to a 1956 interview, it was suggested that the location had been washed away, suggesting it was located on the river bank (Kennedy 2011:47). The same participant mentioned a graveyard at an unspecified location on the north bank of the Peace River, where he said that pans, guns, and ribbon had been left in grave houses.

Additional graves were reported “down from Bear Flats” [sic] (Kennedy 2011), although the precise location was unknown to the participant. The same person mentioned graves on the south bank of the Peace, which may have eroded away. According to the Doig River, Prophet River, West Moberly, and Halfway River First Nations, Dane-Zaa burials are also present in the valley bottom downstream of Bear Flat.

Burials were reported on the former Attachie Reserve, possibly now covered by an agricultural field. The specific location is unknown, but is reported to be along the Halfway River. Additional graves were reported to be under or near an airstrip, around the Attachie school, and possibly near or under the highway near Hudson‘s Hope.

Multiple unmarked Dane-Zaa burials associated with the 1919 flu, including Chief Attachie’s, are reported to be located in the valley. Chief Attachie’s burial is reported to be located on a south facing slope. Other reports of Chief Attachie’s burial place it in the hills near the confluence of the Halfway and Peace rivers, although it is unclear whether on the west or east side of the Halfway, and other burials may be located in the same vicinity.

An old burial, dating to more than 100 years ago, is reportedly near a wagon trail across the river from Old Hudson’s Hope. Dane-Zaa burials, sacred and ceremonial areas are reported on both sides of Peace River near Hudson’s Hope.

An additional burial area was reported to be on a hillside (not the hilltop) near the mouth of the Moberly River. The location was known for saskatoon berries and is near the old fort. Burials related to Dane-Zaa and Cree battles were reported to be on the south side of the Peace River.

3.2.4.3 Summary

Several of the culturally important locations mentioned in this brief review coincide with locations of archaeological sites found during the Site C Heritage Program. Notable examples include the Bear Flat – Cache Creek locality, the mouths of the Halfway River, Lynx Creek, Dry Creek, and Farrell creeks, and the vicinity of Hudson’s Hope. These areas are further discussed in Section 5.2.5.5.

4.0 PALAEONTOLOGY

The palaeontological assessment of the Project was initiated in 2010 by conducting background research at various data repositories to determine the location of known palaeontological sites and to identify potentially fossiliferous geological strata. Information gathered through this literature review was then applied to the LAA and used in conjunction with an aerial photograph review to create a palaeontological potential model. This potential model was then used to guide field work and adjustments were made to the model based on field observations. Further, samples gathered during field work were analyzed using palaeontological data collected during background research. Collected data from identified palaeontological resource locations were analyzed to assess the location's palaeontological significance using a checklist of criteria developed specifically for the Project. The methods employed in conducting the palaeontological resources assessment are presented in the sections below, followed by a discussion of the results of background research, field work, and analysis.

4.1 Palaeontology Methods

4.1.1 Background Literature Review Methods

A considerable amount of geological and palaeontological data is available for the Peace Region. The following section summarizes documentary sources that were reviewed, and data repositories that were queried for the palaeontological assessment.

4.1.1.1 Palaeontological Documentary Research

In 2010, the palaeontological component focussed on background research necessary to characterize the local geology and current palaeontological knowledge, and to guide the palaeontological field assessment. The initial palaeontological overview assessment (Golder and AMEC 2011) focussed on the proposed reservoir, dam site, and portions of the spillway; this overview assessment was expanded later in 2010 (Golder and Branta 2012) to capture additions to the LAA. Prior to field work in 2012, a preliminary scoping exercise was conducted on a further revised LAA resulting in the identification of additional palaeontological sensitivity areas. As the assessment progressed, documentary research was continued and expanded to search for illustrated comparative materials that could assist with the identification of fossils encountered during fieldwork, and to present information from recent publications.

Initial background research included a review of previous work to identify data gaps, determine potential stakeholders, and find additional information repositories or other local sources of palaeontological data. Available palaeontological and geological data were compiled for the area between Taylor, B.C. and the W.A.C. Bennett Dam, including an approximately 10 km wide area between those locations and an approximately 5 km area surrounding proposed quarries at Portage Mountain and a second location near the Pine Pass along Highway 97, south of Chetwynd, BC. In addition, palaeontological sites known to exist in similar geological stratigraphic units as that occurring in the LAA, but found in distant locations (e.g., ammonite sites near Grand Cache, Alberta) were also reviewed and results were incorporated into the assessment. Potentially fossiliferous stratigraphic units that coincide with natural and man-made exposures occurring in the LAA were identified and targeted for field study.

Beyond the LAA, research was conducted to review known fossil localities, characterize the palaeontological resources regionally, and to develop criteria for evaluating the significance of palaeontological sites occurring in the LAA. Correlative palaeontological sites and their fossil assemblages located beyond the LAA were sometimes used to supplement the determination of the palaeontological potential of the stratigraphic units occurring within the LAA and to predict the types of fossils that might be encountered.

4.1.1.2 Palaeontological Data Sources

Information regarding known and potential palaeontological resources in the LAA is based on a search of relevant literature, databases, and maps held by various repositories. Collected literature served as a source for site-specific data collection, spatial information, and to determine the types of fossils previous researchers encountered.

The following sources were accessed for this study:

- Branta in-house palaeontological library
- Royal Tyrrell Museum of Palaeontology (RTMP) database
- The Alberta Museum Palaeontological database
- BC Provincial Heritage Register
- Royal British Columbia Museum
- Geological Survey of Canada Library, Calgary
- Database of unpublished, confidential internal reports of the Palaeontological Subdivision of the Geological Survey of Canada
- Geoscience Data Repository, Earth Science Sector, Natural Resources Canada
- BC Geological Survey on-line GeoFile database
- FossilSites.com, an independent online source for fossil sites in North America
- Canadian Geoscience Knowledge Network (Lexicon of Canadian Geological Names on-line and Canadian Geoscience Knowledge Network data catalogue)
- Palaeontologists with experience in, and knowledge of the palaeontological resources in the Project (e.g., Dr. Terry Poulton, Dr. James White, and Ming Ping at the Geological Survey of Canada, Dan Spivak at the Royal Tyrell Museum of Palaeontology, and Dr. Richard Hebda at the Royal British Columbia Museum)

The sources above provided numerous documents including maps, data tables, publications, and reports that were used to plot locations with known palaeontological resources in or directly adjacent to the LAA.

4.1.1.3 Palaeontological Resource Modeling

Considering the information gathered during background research and literature review, a review of digital aerial photography and LiDAR imagery was conducted to identify locations in the LAA that contain exposed and potentially fossiliferous bedrock, and locations where exposed Quaternary sediments are present. These data were synthesized with known palaeontological site locations and marked with colour-coded polygons that reflect the perceived palaeontological potential (or sensitivity) of a location (Figures 4.5, 4.6.1 to 4.6.31). Palaeontological sensitivity was initially assessed as extreme through low using the following criteria:

- Extreme Sensitivity - purple polygons indicate locations with known palaeontological resources where additional fossils are likely to be encountered
- High Sensitivity - red polygons indicate locations with high potential for finding palaeontological resources, typically due to the presence of steep slopes and extensive exposures that correlate with bedrock formations known to contain fossils elsewhere
- Medium Sensitivity - orange polygons indicate locations that have restricted or intermittent exposures with thin vegetation cover. In addition, lands with extensive exposures just beyond the confines of the Project are noted as medium sensitivity
- Moderate Sensitivity - yellow polygons indicate locations that have limited potential to encounter palaeontological sites. These locations are generally related to gravel bar exposures where Quaternary remains or *ex situ* fossils might be encountered
- Low Sensitivity – locations with low sensitivity are not specifically identified but may include areas with dense vegetation, thick silt deposits, or areas that contain bedrock exposures that are typically void of fossil materials

The identified palaeontological sensitivity areas are “windows” to the palaeontological potential of adjacent, underlying, and correlative sediments that are obscured from direct visual inspection by soil, vegetation, or glacial overburden. In addition, these “windows” can serve as proxy sections to some locations that could not be inspected due to land access difficulties or safety concerns.

Beyond the desk-based palaeontological resource model, field work afforded an opportunity to review the LAA and identify other areas with exposed potentially fossiliferous bedrock that could not be identified through the map review. In instances where areas of palaeontological potential were observed during field work that are not included in the model, the model was revised by adding palaeontological potential polygons to the model dataset. In addition, based on the results of field work areas initially identified as having some level of sensitivity were sometimes downgraded to a new category of sensitivity “Negligible Sensitivity” to identify areas that have little to no palaeontological prospection value. This new sensitivity category is not meant to capture locations in the LAA that are considered to be of low sensitivity which are not specifically identified in the palaeontological potential model.

Overall, the model was effective in predicting the location of palaeontological resources, and accurately reflected conditions observed in the field. For a detailed review of model efficacy, see Section 4.2.1.5.

4.1.1.4 Communication with Regional Authorities

To receive feedback on the methods and scope of the palaeontological assessment, appropriate authorities were contacted through various stages of the assessment to discuss methods, assessment plans, and preliminary results. These include:

- Richard McCrea, the Curator of Palaeontology at Peace Region Palaeontology Research Centre of the Tumbler Ridge Museum Foundation, Tumbler Ridge, BC
- Dr. Richard Hebda, the Curator of Botany and Earth History, Royal British Columbia Museum and science advisor in Palaeontology for the Province of British Columbia in Victoria, BC
- Elisabeth Eldridge, Land Policy Analyst at the Land Tenures Branch for the Province of British Columbia in Victoria, BC
- Palaeontologists at the Geological Survey of Canada in Calgary and Vancouver, including Dr. James White, Dr. Terry Poulton, and Dr. Sandy McCracken (Chief Palaeontologist) in Calgary, AB and Dr. James Haggart in Vancouver, BC
- Heather Longworth, the Museum Manager - Curator of the North Peace Museum in Fort St. John, BC
- Evelyn Sim, the President of North Peace Historical Society, in Fort St. John, BC
- Elinor Morrissey, the Manager and Curator of the Hudson's Hope Museum, Hudson's Hope, BC
- Ross Peck, President of the Hudson's Hope Historical Society, Hudson's Hope, BC

Comments and suggestions from these communications, where appropriate, were incorporated into the scope and methods of the palaeontological assessment.

4.1.2 Field Survey Methods

Palaeontological field assessment was conducted over two field seasons by two crews. Field crews focused on reviewing identified extreme, high, and medium sensitivity polygons. Areas of moderate sensitivity were generally not surveyed unless they were encountered en route to other areas with higher rated sensitivity. Access to these areas was facilitated by 4 x 4 trucks, ATV, jet boat, hiking, helicopter, or a combination of these methods.

Within the surveyed areas of palaeontological sensitivity, crews conducted pedestrian reconnaissance along the base of bluff faces to search for palaeontological sites. Where fossils were found at the bluff bases, and conditions were deemed safe, the palaeontological crew ascended bluff slopes to determine the stratigraphic source location for dislodged fossils. However, if talus slopes were considered unstable, especially in locations with steep scree slopes and unconsolidated Quaternary gravels, inspection was limited to the lower levels of the slope.

In locations where pedestrian reconnaissance was not possible because of steep cliff faces descending into deep or fast-moving water, boat-based inspections were conducted. Boat-based survey generally occurred along the banks of tributaries of the Peace River, or along the banks of the Peace River between Hudson's Hope and the Highway 29 Bridge across the Peace River. An attempt was made to conduct field work in the late summer when water levels in the Peace River were lowest. Despite this effort, high water levels in the Peace River persisted through both summers during the field study.

Palaeontological sensitivity polygons were geo-referenced in a GIS and plotted on maps of the LAA. Hand-held GPS units were used to confirm position in relation to Project mapping, to collect transect location data, and to acquire coordinates. Waypoints were generally acquired by the crews at:

- Photograph view points
- Identified fossils
- Locations requiring notes about observed geological formations

4.1.2.1 Documentation of Fossil Occurrences

When fossils were observed, the general form of the specimen, context, condition, taphonomy, and stratigraphy were noted. Digital photographs and GPS coordinates were taken for each general collection or assemblage of fossils, rather than for each individual fossil. In addition, a photograph of the exposure from which the fossil was derived was taken. Fossil occurrences were tabulated in spreadsheets that record the individual palaeontological sensitivity area, associated waypoint numbers, fossil taxonomic names or descriptions of trace fossils, and observed fossiliferous geological strata. For each taxon observed, a relative abundance indicator and species identification certainty indicator is provided using the following indices:

- X = single occurrence
- R = rare occurrences (2 to 5 specimens)
- C = common occurrences (6 to 20 specimens)
- A = abundant occurrences (>20 specimens)
- ? = a tentative species identification

4.1.2.2 Fossil Collecting and Curation

Fossils were collected for three reasons:

- To provide material for enhanced specimen identification and confirmation
- To salvage significant fossils, as exposed fossils are at risk from erosion, destruction from freeze-thaw cycles, and removal by amateur collectors
- To acquire a representative collection of fossils to indicate the condition, composition, and abundance of an assemblage from within various stratigraphic units at palaeontological sensitivity areas

In a number of instances, where the river flow or steep slopes did not allow for detailed scrutiny, whole and relatively unweathered concretions were collected. These concretions are expected to contain fossils and have been retained to be opened in a controlled setting.

All collected fossil material is to be catalogued and submitted to a recognized provincial repository for curation, in consultation with stakeholders and on advice from the palaeontological curator of the Royal British Columbia Museum. For curation, each collected specimen will be assigned a unique number that can be referenced back to the collection location. Individual fossils will be digitally photographed with an appropriate scale bar and other information will be provided, as available, to fulfill the Royal British Columbia Museum's standard fossil curation spreadsheet.

4.1.3 Analysis Methods

Data collected during background research were synthesized with field observations and collected samples in an attempt to refine species identification. Experts familiar with similar fossil assemblages were queried where appropriate to assist with species identification.

4.1.4 Significance Assessment Methods

The significance of identified palaeontological sensitivity areas varies widely and, for the purpose of this report palaeontological significance has been assessed using the method presented below. This significance evaluation differs from the assessment of the significance of residual Project effects.

For the evaluation of palaeontological resources, a significance checklist was developed using four categories (scientific, educational, heritage, and commercial) provided in the following documents: *Fossil Management Framework Consultation Summary Report* (Ministry of Agriculture and Lands 2010), *Fossil Management Plan for British Columbia* (Fossil Management Review Technical Working Group 2004), and palaeontological resources of the *Dawson Land Resource Management Plan* (Haggart, et al. 1997). Additional guidance was taken from criteria used in other North American jurisdictions for the protection and management of palaeontological resources. This effort resulted in the significance criteria and categories presented below in Table 4.1.

4.1.4.1 Significance of Positive Palaeontological Sensitivity Areas

The characteristics of each positive palaeontological sensitivity area encountered during the assessment of the Project are considered against an established and ordered set of significance components, categories, and elements that consider several variables. This exercise produced an overall palaeontological significance score for each positive palaeontological sensitivity area. The resulting ranking of palaeontological sensitivity areas provides a systematic way to formulate mitigation recommendations that reflect the importance of these locations.

The *Fossil Management Plan for British Columbia* (Fossil Management Review Technical Working Group 2004) proposes four components of palaeontological significance in order of importance: scientific, heritage, educational, and commercial significance. Following this established significance component ranking system, a checklist of categories containing specific elements for consideration were developed that were used to assess each significance component. Each element is posed as a 'yes' or 'no' question and the sum of all 'yes' answers was used to rank the positive palaeontological sensitivity areas against one another. In some instances there was not sufficient information to answer a question; the sum of all 'insufficient' answers was then used in comparison with sum of absolute answers to determine the degree of certainty associated with each location's significance assessment. Table 4.1 summarizes the palaeontological significance criteria that were used in the checklist. An example of the checklist is provided as Appendix C.

Table 4.1: Palaeontological site significance criteria weighting

Component	Category	Number of Elements
Scientific (41*)	Taxonomy	9
	Evolution	7
	Biostratigraphy	8
	Palaeoecology	8
	Taphonomy	6
	Methodology	3
Heritage (9*)	Recognition	3
	Visitation	3
	Landmark	3
Educational (8*)	Institutional	4
	Public	4
Commercial (8*)	Saleability	4
	User-benefits	4
	Total of Categories = 13	**66**

NOTES:
*total number of element points possible per category

4.1.4.1.1 Scientific Significance

The scientific component of palaeontological significance evaluation is any aspect that potentially contributes to palaeontological knowledge. As this component is deemed the highest ranking, six categories were established, each with its own set of elements to be considered. The following categories are considered when assessing the scientific significance of a palaeontological resource.

1) Taxonomy: the categorization and description of fossils, so that they can be named and systematized to advance understanding of the palaeobiotic “geoinventory” of life on earth

2) Evolution: the comparative and experimental study of fossils to aid in the interpretation of the origin and development of life through geological time

3) Biostratigraphy: the use of fossils in the application of palaeontological principles to establish stratigraphic frameworks in time and space

4) Palaeoecology: the integrative analysis of fossils to clarify the relations and interactions of palaeobiota with their ancient environments

5) Taphonomy: the preservation or alteration of an organism through the process of fossilization

6) Palaeontological Methodology: the experimental potential of the resource to develop new or improved palaeontological methods

Palaeontological sensitivity areas with high scientific significance could include locations with large fossil specimens, rare forms, and fossils that require special preservation conditions (e.g., large vertebrate fossils) which are considered unique and irreplaceable. However, factors that could detract from a site's scientific significance include locations with poor specimen preservation, a lack of stratigraphic and palaeoenvironmental context.

4.1.4.1.2 Heritage Significance

The heritage component of palaeontological significance evaluation is any aspect that potentially expands, enhances or impinges on the presiding understanding of human history, origins, cultural traditions, and practices of the stakeholders of the area. Palaeontology is considered to be part of the natural collective inheritance of a society.

Heritage significance values can be enhanced through a palaeontological sensitivity area's proximity to other heritage sites or acknowledged landmarks. Significance values can also be enhanced if the palaeontological sensitivity area has been used recreationally by amateur fossil collectors; and if a site is embedded into the cultural or historical fabric of First Nations or other communities.

4.1.4.1.3 Educational Significance

The educational component of palaeontological significance evaluation is any aspect that can contribute positively to the educational process or teaching environment of institutions, students, and the general public; either locally, regionally, nationally, or internationally.

Educational significance values can be enhanced by the desire of institutions (e.g., museums, universities, colleges, or schools) to incorporate the fossils or palaeontological sites into their collections, displays or curricula. Palaeontological resources that have topical and contextual integrity could have high educational value.

Fossils that are poorly preserved or highly fragile may have reduced value for teaching demonstrations. Fossils with less educational value may be useful materials in the education of younger students and during public forums.

The utility of individual fossils and palaeontological sites in public interpretative programs are also considered. Locations that have easy access, are esthetically pleasing, or have readily visible palaeontological features could have interpretive value. However, the safety of visitors due to steep cliffs or falling rocks or remoteness can detract from a site's utility for these educational endeavours.

4.1.4.1.4 Commercial Significance

The commercial component of palaeontological significance evaluation is any aspect of that resource that has an inherent monetary value (e.g., marketing fossil organisms, commercial potential of interpreting palaeontological sites). According to the *Fossil Management Plan for British Columbia* (Fossil Management Review Technical Working Group 2004), the commercial value of palaeontological resources has the lowest priority of all of the above significance categories. Preferred mitigation practices seek to enhance the interests of scientific, heritage, and educational concerns.

Well-preserved, interesting, rare, and esthetically pleasing fossils hold the highest market value. Fossilscapes (slabs of rock that have multiple fossils) have enhanced commercial significance as display items because they exhibit the deposition and past living relationships of the fossils. Areas with concentrated palaeontological resources that can be "mined" for fossils may attract commercial interest by lowering the costs and time required to recover fossils, increasing profitability of the mining, preparation, and marketing of the fossils. However fossils that are poorly preserved, unidentifiable, inconspicuous, or readily available have lower commercial significance.

4.1.4.2 Site Class Determinations

In an effort to provide mitigation recommendations for positive palaeontological sensitivity areas the overall significance rankings (e.g., the total number of 'yes' answers) of each palaeontological sensitivity area were compared against each other to determine the mean score, and locations on either side of the mean were ordered according to percentile. The result of this exercise was then plotted on a line graph alongside the certainty percentage scores for each location. Obvious changes in the graph were then used to guide the determination of a location's class. A three-tier system of classification was employed (i.e., Class I, Class II, and Class III).

- Class I palaeontological sensitivity areas are considered the most important locations and may contain unique fossils *in situ*, abundant and diverse specimens, good specimen preservation, have multiple time depths represented, and may have potential educational opportunities, or commercial opportunities
- Class II palaeontological sensitivity areas are considered moderately important and may contain commonly known fossils *in situ*, moderate preservation, moderate abundance, and sometimes coincide with areas where amateur fossil collection has taken place
- Class III palaeontological sensitivity areas are those locations that have low specimen abundance, poor preservation, and common specimens in *ex situ* context

4.2 Palaeontology Results

Palaeontological background literature review results are provided below, followed by field assessment results. Results of the palaeontological significance evaluation are provided in Section 7.1.

4.2.1 Background Literature Review Results

The LAA is underlain by potentially fossiliferous sedimentary bedrock, including conglomerates, marine shales, non-marine shales and sandstones (Irish 1958). In addition, a veneer of Quaternary aged sediments overlays the bedrock in portions of the LAA and could contain more recent fossils. Further discussion of bedrock and surficial geology in the context of known palaeontological resources is presented below.

4.2.1.1 Geological Settings in the LAA

Considering that the LAA includes a wide geographic area, there is variation in the underlying geology. To address this variation, the LAA has been broken down into three logical geographic subsections to facilitate the discussion of the different geological strata present in each of these areas.

4.2.1.1.1 Peace River Valley

Project components in the Peace River valley include the proposed dam and generating station, reservoir, transmission system, select quarried and excavated construction material sources, Highway 29 realignment, access roads, and the Hudson's Hope Shoreline Protection. These components are situated primarily within the Alberta Plateau Physiographic Region (Figure 4.1, 4.2, 4.4, 4.5, 4.6.1 to 4.6.30, 4.7, and 4.8.1 to 4.8.30). A thick veneer of unconsolidated Quaternary sediments exists throughout this portion of the LAA and masks much of the bedrock topography (Severin 2004). Underlying the Quaternary sediments are non-marine to marine Middle Cretaceous rocks. These sedimentary rock layers are part of the Fort St. John Group and dip flat, to gently. These bedrock layers date from between the Early Albian to Earliest Cenomanian age. To the east, and away from the Peace River, the Fort St. John Group is overlain by alluvial to deltaic rocks of Cenomanian age, comprising the Dunvegan Formation. This Cretaceous stratigraphy has been mapped most comprehensively by Stott (1982). Minor alterations have been made to Stott's original geological map by MacIntyre, et al. (2002) and Legun (2005).

4.2.1.1.2 Portage Mountain

The Portage Mountain Quarry is situated along the northeastern front of the Rocky Mountains Physiographic Region on the northwest slope of Portage Mountain which is situated north of the Dinosaur Lake reservoir and south of the W.A.C. Bennett Dam (Figures 4.1, 4.2, 4.4, 4.5, 4.7, and 4.8.31). A major geological structural complex encompasses the quarry and comprises a north-by-northwest to south-by-southeast trending anticlinal and synclinal folding with thrust and faulting of primarily Lower Cretaceous strata. Bedrock within the quarry is Early Cretaceous (Barremian to Early Albian) in age and embraces the Cadomin Formation and the Gething Formation of the Bullhead Group, as well as the Moosebar Formation which is basal to the Fort St. John Group. Within the foredeep, thick piedmont deposits with abundant coals grade into deltaic sediments northward across the Peace River (Glass 1990). Proxy locations for these geological strata are exposed extensively along the Peace River Canyon to the south, and intermittently along the valley walls of Williston Lake to the west.

4.2.1.1.3 Pine Pass

The proposed West Pine Quarry is located along the north slopes of the Pine River Valley, east of Silver Sands Creek, north of Mount Le Moray, and east of Solitude Mountain at the north approach to the Pine Pass (Figures 4.1, 4.4, 4.5, 4.7, 4.6.31, and 4.8.32). The local stratigraphy, comprising primarily limestone lithologies, encompasses the Rundle, Stoddart, Spray Lake, and Schooler Groups. The proposed West Pine Quarry is situated within the Foreland Fold Belt, which consists of intensely deformed strata that represents the eastern limit of rock deformation, related to amalgamation of the more westerly tectonic terrains with the western margin of Pangaea (Gabrielse and Yorath 1989; Wheeler, et al. 1991).

The West Pine Quarry area is directly underlain by rocks of the Carboniferous Rundle Group and Stoddart Group, the Triassic Spray Lakes Group and the Fernie Group in repeated folded and thrusted stratigraphic packages. Post-Rundle to pre-Spray Lake sediments were removed, primarily by erosion or peneplanation. The dominant tectonic elements affecting sedimentation in the region is the Peace River Embayment, a broad fault controlled re-entrant into the western cratonic platform that opens into the Prophet Trough to the west (Richards, et al. 1994).

4.2.1.2 Stratigraphic Review

The following is a summary of the potentially fossiliferous bedrock and surficial geology that can be found within the LAA (Figures 4.1, 4.2, and 4.3). Consistent with professional palaeontological practice, the geological strata described below is presented in descending order with oldest, potentially fossiliferous layer described first.

4.2.1.2.1 Carboniferous

Rundle Group (Early Carboniferous: Late-Early Tournasian to Late Visean)

Sediments of the Rundle Group were deposited from the Late-Early Tournaisian to the Late Visean and represent an overall shallowing upward sequence represented by predominately carbonate platform lithofacies with subordinate carbonate ramp lithofacies and basinal to supratidal siliciclastics (Richards, et al. 1994). Locally, and in most of the Prophet Trough and western graben portion of the Peace River Embayment, the dominant shallow marine platform and ramp carbonates of the Rundle Group prograde basinward over the deep water shales and carbonates of the Besa River Group.

The Rundle Group rocks can be highly fossiliferous, containing a wide variety of invertebrate fossils, such as brachiopods, bryozoans, crinoids, echinoderms, corals, foraminifers, gastropods, organic pellets, and pelecypod (Rutgers 1958; Williams and Bocock 1932). Rare vertebrate fossils comprise fish and other unidentified skeletal elements (Langston 1959; McGuagan and Rapson-McGuagan 1976).

Stoddart Group (Latest Early to Late Carboniferous: Late Visean to Moscovian)

The carbonates and black shales of the basal Golata Formation of the Stoddart Group unconformably overlie the Rundle Group. Major, basin-wide inter- and intra-formational unconformities are evident within the Stoddart Group due to episodic structural uplift (Barclay, et al. 1990). Regionally overlying the Golata Formation, are the sandstone-dominated estuarine, deltaic, and deltaic-related slope to peritidal deposits of the Kiskatinaw Formation. The base of the overlying Taylor Flats Formation consists of outer slope marine sandstone and shale, which are in turn, overlain by restricted shelf carbonates and evaporates, and finally ramp carbonates. A final regression took place after the Muscovian and prior to the Permian, which exposed nearly all of the Western Canada Sedimentary Basin to subaerial erosion (Richards et al. 1994).

The Stoddart Group can be highly fossiliferous comprising mainly invertebrates such as brachiopods, horned corals, bryozoans and crinoids with rare fish skeletal elements (Irish 1963; Langdon 1959; Williams and Bocock 1932). Macrofossils in the West Pine Quarry area, hydrozoan, molluscan, and minor echinoderm fossil material have been recovered from an unnamed formation of Late Carboniferous age, which may by correlative to the Taylor Flats Formation of the Stoddart Group.

4.2.1.2.2 Triassic

Unconformably overlying the Stoddart Group is strata of Triassic age but the entire Permian to Early Triassic age formations are absent in this location. Triassic sediments were deposited within a mixed siliciclastic-carbonate system on the western edge of the North American craton (Zonneveld, et al. 1997). In northeast British Columbia the Triassic strata is subdivided into the Daiber Group of early to middle Triassic age and the Schooler Creek Group of late-middle to late Triassic age (Edwards, et al. 1994). These two groups combined are equivalent to the Spray Lakes Group found in southeast British Columbia. In the area of the West Pine Quarry, only the later Schooler Creek Group has been mapped in exposures. However, despite not being recorded in the region previously, there is some potential of encountering the older Daiber Group strata during excavation activities.

Daiber Group (Lower Triassic: Griesbachian to Ladinian)

In other regions, the Diaber Group overlies the Stoddart Group and represents bedrock of Early to Late Triassic age. Grayling and Toad formations observed in southwest British Columbia are stratigraphically equivalent to the Montney and Doig formations that are known to occur in the eastern Alberta foothills and plains. The basal Grayling Formation, which overlays Permian rocks discomformably, consists of a succession of recessive siltstone, shale, and lesser amounts of limestone and shale. It is overlain by the Toad Formation, which consists of dark gray siltstone, silty limestone, shale, and lesser amounts of dolostone and sandstone.

Diaber Group rocks are not expected to be encountered at the West Pine Quarry. However the potential to find Lower Triassic strata equivalent to those found in Kakwa Provincial Park, near the British Columbia and Alberta boundary, still exists. A unique and well preserved fish fossil assemblage consisting of over 1,000 specimens, including elasmobranchs, coelacanths, and armored fish occurs near Wapiti Lake, approximately sixty kilometers south of Tumbler Ridge; this assemblage represents an important link between ancient Paleozoic fishes and modern teleost fishes (Haggart, et al. 1997; Neuman 1996; Mutter, et al. 2008; Edwards, et al. 1994). Other identified vertebrate fossils include those of ichthyosaurs, plesiosaurs, thalattosaurs, and diaspids (Haggart, et al. 1997). Also found at the Wapiti Lake site, within and between the fish beds, are invertebrates such as brachiopods, bivalves, gastropods, rugose corals, crinoids, ammonites, and phylocarid and other arthropods (Mutter and Neuman 2008).

Schooler Creek Group (Lower Triassic: Ladinian to Rhaetian)

The Schooler Creek Group comprises the Ludington Formation and its stratigraphic equivalents Liard, Charlie Lake, and Baldonnel Formations, as well as the overlying Pardonet. Sitting transitional from the Middle to Late Triassic, the basal Liard Formation consists of sandstone, siltstone, dolostone, and finely crystalline skeletal limestone. The Liard Formation is conformable overlain by the carbonate sandstones, siltstones, sandy limestones, dolostones, and minor breccias of the Charlie Lake Formation. The Charlie Lake Formation is conformably overlain by the Baldonnel Formation and local inclusions of the Ducette Formation, consisting of limestone, calcareous and dolomitic siltstone, and occasional fine grained sandstone. The Baldonnel Formation is abruptly overlain by the Pardonet Formation, which consists of dark weathering limestone, calcareous and dolomitic siltstone, and shale. The limestone is skeletal often consisting of whole and fragmented bivalve shells. The Pardonet Formation represents the final phase of a Late Triassic marine transgression along the northwest coast of Pangaea (Nicholls and Manabe 2004). In the West Pine Quarry area, the Pardonet Formation may be overlain by the Bocock Formation consisting of finely crystalline to bioclastic limestone. The Jurassic Fernie Formation unconformably overlies the Triassic, just east of the West Pine Quarry (Edwards, et al. 1994).

The fossil assemblages of the Schooler Creek Group are locally diverse and abundant. The Ludington Formation and equivalents yield various invertebrate fossils including brachiopods, echinoids, gastropods, crinoids, decapods, and pelecypods. Vertebrate elements include fish and marine reptilian forms. The Pardonet Formation has a rich invertebrate assemblage of pelecypods, ammonites in association with fish and marine reptilian elements. The Bocock Formation of Rhaetian age has yet to produce significant macrofossils.

4.2.1.2.3 Jurassic

Fernie Formation (Early, Middle and Late Jurassic)

The Jurassic to Cretaceous strata in the Pine River Valley comprise the Jurassic Fernie Formation (Group) and the Upper Jurassic to Cretaceous Kootenay Group, which unconformably overlie the Triassic. The Fernie Formation (Group) is a long ranging marine phosphatic shale-dominated unit with limestones siltstones and sandstones deposited on the Pre-orogenic western platform (Poulton, et al. 1994) through most of the Jurassic and develops initial orogenic clastic wedges in the Tithonian to Berriasian. The basal Nordegg Member comprises a cherty limestone. This is overlain by the Toarcian to Aalenian Poker Chip shale and subsequently by the locally deposited Middle Jurassic Rock Creek sands. Locally in the northwest British Columbia a persistent hiatus encompasses the Middle Jurassic, although Middle Jurassic fossils are recorded on Le Moray Mountain (Hughes 1967). The subsequent Upper Fernie Formation comprises Oxfordian “Green Beds” interbedded with the Niton sands. The Jurassic to earliest Cretaceous beds have complex relationships with the Upper Fernie Formation being transitional to the north by Nikinassin and to the south by the Passage Bed, while overlain by the basal Cretaceous Minnes Group in the Pine River area. In the local vicinity of the West Pine Quarry, Jurassic strata occur along the east boundary and as small slices between the repeatedly thrust faulted Palaeozoic strata.

Within the Lower Fernie Formation invertebrate fossils such as ammonites, belemnites brachiopods, crinoids, and pelecypods can be common in these shales and sandstones; however they can be rare and poorly preserved to the east in the Mt. Bickford and Carbon Peak area (McLearn 1940; Mathews 1946). The Upper Fernie Formation is characterized by the presence of ammonites and buchid pelecypods. The algal cysts of dinoflagellates have been extracted from Fernie and Montieth Formations (Davies and Poulton 1986; Poulton, et al. 1990). Vertebrate fossils are extremely rare, primarily in the Lower Fernie Formation as occasional fish and dispersed reptilian bone material.

4.2.1.2.4 Cretaceous

Minnes Group (Jurassic to Lowest Cretaceous)

Macrofossils can be present in the Upper Minnes Group as demonstrated by local invertebrate fossil assemblages at Mount Le Moray (Stelck in Mathews 1946) to the south of the West Pine Quarry, and include belemnites, gastropods, and brachiopods.

Bullhead Group (Early Cretaceous)

The stratigraphic unit referred to as the Bullhead Group was first established by McLearn (1918) as a formation encompassing the non-marine coarse clastic sequence overlying the Triassic shales and underlying the Fort St. John shales, which occur along the Peace River Valley south of Bullhead and Portage Mountains; its formation status was upgraded to a group by Wickenden and Shaw (1943). A comprehensive history of the development of

the stratigraphic nomenclature has been traced by Stott (1973:7-11). The Bullhead Group is stratigraphically equivalent with the lower Luscar Group of the northern and central Rocky Mountain Foothills, the Lower Blairmore Group of the southern Rocky Mountain Foothills, and the lower Mannville Group of Alberta (Hayes, et al. 1994 – see Figure 4.3). In addition, this stratum is considered equivalent to the Crassier Group, as defined by Hughes (1964), of the Peace River and the Pine River foothills.

Cadomin Formation (Barremian to Early Aptian) – the basal formation to the Bullhead Group is the Cadomin Formation including the abandoned equivalents, the Brenot Formation and the overlying Dresser Formation. This formation comprises massive coarse clastics with characteristic conglomerates forming prominent exposures. Coal deposits are occasionally present in this braided stream complex. This Barremian to Early Aptian age stratigraphic unit is equivalent to the basal portions of Cutbank Sandstone, Ellerslie Formation and McMurray Formation in the plains of Alberta. Along the west side of Bullhead Mountain, Legun (1993) describes the Cadomin Formation as pebbly sandstone, in part conglomeratic up to 200 m thick with a thin basal coal bed, sharp in contact with the underlying Monach Formation. The Cadomin Formation forms the central bedrock of Bullhead and Portage Mountains.

Within the Cadomin Formation well-preserved fossils are rare. According to Stott (1973:29), the Cadomin Formation has coalified drifted logs and stumps, but few identifiable fossils. Dinosaur footprints (Currie 1978) occur near the upper formational boundary (Weishampel, et al. 2007). However, they may be included in the overlying Gething Formation due to the more gradational character of the boundary in the Peace River Canyon (Stott 1968).

South of the Portage Mountain Quarry, along the north bank of the Peace River Canyon and flanking of the south side of Portage Mountain, the Cadomin Formation contains rare well preserved fossil leaves and other plant debris and woody material (Hughes 1964), including *Pityophyllum nordenskoildi?* indicating a Neocomian to Aptian age. In addition, Hughes (1964) records conifers and ferns from the overlying Dresser Formation from Grant Knob in the Peace River Canyon.

Gething Formation (Aptian to Early Albian) - the upper coal-bearing interval of the Bullhead Group is the Gething Formation, which is renowned for its fossil content. The coarsening upward sequence of Aptian to Early Albian age comprises a lithology of interbedded mudstone coal and sandstone (Stott 1968) which may have conglomerates occasionally. It was originally defined for exposures along the Peace River. Most complete exposures occur within the Peace River Canyon in the vicinity of Aylard Creek (Stott 1968: Type section – starting at 55° 58'N, 122° 13'W to 55° 58'N, 122° 10'W). There, the sandstones fine upward into marine siltstones with up to 168 m of accumulation along the Peace River Canyon. The Gething Formation forms the bedrock around the skirts of Bullhead and Portage Mountains. The Butler Ridge outcrop described by Stott (1968) is located just to the northwest of the Pringle Quarry where a discontinuous section of prominent sandstones, alternating with partially covered siltstones and coals is exposed. Fossils were not noted in this location; however, in other locations the Gething Formation is highly fossiliferous, especially along the Peace River Canyon (Dinosaur Lake) with common coal seams, ironstones, and sandstones offering excellent preservation potential.

Fossils were first observed by Alfred Selwyn in 1887 at Cust's House along the west flank of Portage Mountain; he noted sparsely distributed fossils, primarily plants comprising silicified stems and branches with coalified bark, in massively bedded, brown-grey calcareous sandstone with conglomerate and shale beds (Selwyn 1877:45, 63-64). The map arising from that geological excursion (Dawson 1881) indicates the presence of fossil wood (fossil

locality C101). Hughes (1964) also records the fossil cycads and conifers. A gastroplitid ammonites have also been identified by Jeletzky (1961) at Contact Point, along the Peace River and tentatively assigned to the Gething Formation. Along the upper Pine River to the south of the Peace River, Hughes (1964; identified by Jeletzky 1957b) discovered a number of bivalves in the Gething Formation. Regionally, trace fossils are common in the Gething Formation (Currie 1995; Gingras, et al. 2010; Pemberton and MacEachern 1995). Microfossils are also abundant and diverse throughout the Gething Formation (Wall 1978, 1983, 1984) and include foraminifers, thecamoebians, ostracods, gastropods, pelecypods sponge spicules, crinoids, fish teeth and scales, radiolarians, as well as the algae diatoms, and charophytes and plant seeds. The local macroflora comprises fossil leaves, stems, large prostrate logs, vertical rootlets and upright stumps, ferns, cycads, and conifers (Stott 1968). Fossil leaf imprints tend to occur in the roof shales overlying the coal seams. Local fossil flora has been obtained from exposures at Grant Knob in the Peace River Canyon (Hughes 1964). A well-preserved tree trunk, one metre in diameter and length, was recovered from the east side of the Peace River Canyon by Legun (1983).

The Fort St. John Group

Within the Lower Cretaceous, the Fort St. John Group disconformably overlies the Gething Formation of the Bullhead Group and is divided, from the base upward, into the Moosebar, Gates, Hulcross, Boulder Creek, Hasler, Goodrich, and Cruiser Formations. Within the LAA, the Gates, Hulcross, and Boulder Creek Formations are equivalent to the Commotion Formation, which has been mapped as one unit in the southwest portion of the LAA by Irish (1958) and Stott (1982). The sandstones of the Goodrich Formation are absent, and the Hasler through Cruiser sequences have been included in the Shaftsbury Formation, and will be designated as such in this report and in the following formation summaries which were derived primarily from Stott (1982) and Canadian Geoscience Knowledge Network (No Date).

Moosebar Formation (Early Albian) - the Type Locality of the Moosebar Formation, the lowest formation of the Fort St. John Group, is at the southeast end of the Peace River Canyon, at a site that is now inundated by the Peace Canyon Dam (McLearn 1923). The formation occurs throughout the foothills of British Columbia, south of the Peace River and thins into the Alberta Foothills (Appendix N-1, Photograph 1). Approximately 289 m thick at the Type Locality, the formation consists of marine shale and siltstone. The basal, dark grey shale is rubbly to blocky and commonly contains weathered reddish brown sideritic concretions. A thin bed of pebbles and glauconitic mudstone often marks the disconformable contact with the underlying Gething Formation. The silt content increases in the upper beds with silty mudstones and thin platy siltstone occurring toward the top at its gradational contact with the overlying Gates Formation. An Early Albian age is suggested by the presence of the ammonite *Archthoplites irenensis,* which is representative of the lower part of the generalized *Archthopolites* or *Beudanticeras* affine Zone. The benthic foraminiferal assemblage of *Marginulopsis collinsis* and *Verneuilinoides cummingensis* suggests an Early to Middle Albian age.

Gates Formation (Early to Middle Albian) - at the Type Locality (McLearn 1923) the Gates Formation is a massive to thinly bedded, fine-grained, well sorted sandstone, approximately 20 m thick and was deposited in a delta front - coastal shoreline environment (Appendix N-1, Photograph 3). The Type Locality is located along a resistant cliff ("The Gates"), on a rock island in the Peace River east of Hudson's Hope, now known as Gates Island. South of the Peace River, the lithology becomes more varied with a fine grained, well sorted sandstone as a basal unit underlying an upper section consisting of a cyclic succession of carbonaceous sandstone, mudstone, siltstone, coal, and some conglomerate. The contact with the underlying Moosebar Formation is gradational and it is overlain abruptly by the marine shale of the Hulcross Formation. The Gates Formation lies

within the Early Albian *Archthoplites* Zone and the *Marginulopsis collinsi* Subzone and is renowned for its fossil content. A large flora (the Lower Blairmore-Luscar-Gething flora) occurs in the Gates Formation. Over 20 dinosaur track sites as well as bird tracks, pelecypods, and plant fossils are known from the Gates Formation at the Smoky River Coal mine just north of Grand Cache, Alberta, approximately 390 km southeast of the LAA (Royal Tyrrell Museum of Palaeontology 2010).

Hulcross Formation (Early to Middle Albian) - the Type Locality of the Hulcross Formation was designated by Stott (1968) on a ridge north of the Wolverine River, in the British Columbia foothills south of the LAA. The Hulcross Formation, deposited in a predominately marine to delta front environment, consists of rubbly, silty, dark grey shale or mudstone. The silt content increases upward with thinning beds of argillaceous siltstone and platy sandstone along with common to abundant red-brown concretions occurring in the uppermost part. The contact with the underlying Gates Formation is abrupt and most likely disconformable, as there is a distinct contrast from the Gates' sandstones with the dark grey to black shales of the Hulcross. Near its upper contact, the upper Hulcross beds, which are often a succession of interbedded siltstone and shale, are transitional with the thickly bedded basal sandstone of the Boulder Creek Formation. Early Albian fauna of the *Archthoplites* and *Beudanticeras* affine zone are present in the lower sections of the Hulcross Formation, while the upper section has yielded an upper Albian *Pseudopulchellia puttoni* and *Gastropolites* Zone fauna of Middle Albian age. The *Haphophragmoides multiplum* Zone characterizes a large part of the shale now assigned to the Hulcross Formation (Caldwell, et al. 1978; Stelck, et al. 1956:15).

Boulder Creek Formation (Middle Albian) - Stott (1968) defines two reference sections for the Boulder Creek Formation near the LAA at Bullmoose Mountain and Dokie Ridge. The Boulder Creek Formation's Type Locality is along Commotion Creek and measures from 73 m to 171 m thick. The Boulder Creek sediments were deposited in a delta front to coastal marine environment. At its type locality, the formation can be divided into three units: a lower unit of thick bedded to massive, fine grained, well-sorted marine sandstone, a massive middle conglomerate, and an upper coal-bearing succession of carbonaceous shales and argillaceous sandstones. A conformable relationship exists with the underlying marine shales and siltstones of the Hulcross Formation and the overlying marine shales of the Shaftesbury Formation. Ammonites of the Middle Albian *Gastroplites* Zone are found in the Boulder Creek Formation. In addition, the flora is characterized by several species of angiosperms, which mark a major change from the older "lower Blairmore" flora.

Shaftesbury Formation (Late-Middle Albian to Earliest Cenomanian) - a Late Albian transgressive event that inundated the entire Western Canada Sedimentary Basin has deposited a marine shale unit known as the Shaftesbury Formation (Leckie, et al. 1990). Within the LAA, dark grey flaky to fissile rusty weathering shales, mudstones, and siltstones are exposed in addition to ironstone nodules carrying large ammonites (Appendix N-1, Photograph 4). Within the Shaftesbury Formation is "The Fish Scale Zone" - a basin-wide marker horizon that has been interpreted as representing a condensed section deposited during a long period of very slow sedimentation (Leckie, et al. 1992). In addition to being interpreted as marking the Early - Late Cretaceous or Albian - Cenomanian boundary (Caldwell, et al. 1978; Singh 1983), the Fish Scale Zone has been used to stratigraphically subdivide the Shaftesbury Formation into lower and upper units. In addition to abundant fish scales, the zone is composed of sandy shale and thin layers of bentonite. The contact with the overlying Dunvegan Formation is conformable both vertically and laterally, and the contact with the underlying Boulder Creek Formation is conformable with a localized hiatus noted near the town of Peace River, Alberta.

The Shaftesbury Formation is further subdivided in the west portion of the LAA, west of Farrell Creek, into three formations: the Hasler Formation – a lower shale unit, the Goodrich Formation – a middle sandstone unit, and the Cruiser Formation – an upper shale unit. The Cruiser Formation occurs along the upper Maurice Creek in the vicinity of the transmission line corridor. This subdivision is arbitrarily discontinued east of Hudson's Hope and is

designated generally as the Shaftesbury Formation which grades down into the underlying Hulcross Formation. Within the Shaftesbury Formation (below the Fish Scale Zone), the ammonite *Stelckeceras liardense w*as noted on the Peace River, west of the Halfway River, and is considered to be Latest Middle Albian in age. The common presence of the ammonite *Neogastroplites cornutus* on the Peace River between Bear Flat and the east extent of the dam and generating station also suggests a Middle to Late Albian age. The ammonites *Irenicoceras* and *Beattonoceras* noted northeast of the Pine River, within the Shaftesbury Formation (above the Fish Scale Zone), indicate an early Cenomanian age. Many of the ammonites found within the Shaftesbury Formation are endemic. The Shaftesbury Formation is exposed intermittently along the Peace River Valley's walls from Farrell Creek east to the British Columbia and Alberta boundary. Other exposures are present along several of the Peace River's tributaries, such as the Halfway, Moberly and Pine Rivers, as well as Farrell, Septimus, Red, and Cache creeks (Severin 2004).

Dunvegan Formation (Middle/Late Cenomanian)

The Dunvegan Formation of Middle - Late Cenomanian age is a lithostratigraphically defined unit that comprises an extensive, southeasterly thinning and fining, fluvio-deltaic clastic wedge deposited above the Shaftesbury Formation and is confined to northwest Alberta, northeast British Columbia, and extends into the Northwest Territories. The Dunvegan wedge built into the Cretaceous Western Interior Seaway to the fullest extent during the Middle Cenomanian. It consists of interbedded mudstones, sandstone, and conglomerate. Thinner beds of coal and shelly limestone also exist in places (Leckie, et al. 1994). The Type Locality of the Dunvegan Formation is near the town of Dunvegan, on the Peace River in northwest Alberta, where it is dominantly marine in origin. However, into northeast British Columbia, the formation becomes completely continental in nature (Glass 1990). Within the Peace and Pine River areas, the dominant lithologies are fine to coarse-grained sandstone, conglomerate, and carbonaceous shaley coal. It is conformably underlain by the shales of the Shaftesbury Formation and overlain by shales of the Kaskapau Formation, both contacts being highly diachronous (Leckie, et al. 1994).

Key faunal elements of the Dunvegan Formation are the ammonite *Acanthoceras athabascense*, the pelecypods *Inoceramus rutherfordi* and *I. dunveganensis* and the foraminifers *Verneuilinoides perplexus* and *Ammobaculites gravenori*. The Dunvegan Formation is exposed primarily within the uplands portion on the Alberta Plateau north and east of the Halfway and Peace Rivers (Blyth 2008).

4.2.1.2.5 Quaternary to Recent

Four relic drainage systems have deposited the Late Tertiary-Early Pleistocene to post-Wisconsin sediments on various planation surfaces and paleo-straths (ancient wide river valleys) along the present Peace River valley (Hartman and Clague 2003). Generally, the youngest sediments fill the deep present strath and the oldest sediments cap the higher terraces, plateaus and hills. The Pre-Late Wisconsin Laurentide tills have been identified at Old Fort St. John (Mathews 1978; Hartman and Clague 2003). Lake sediments from Glacial Lake Peace and Glacial Lake Mathews (Rutter 1977; Mathews 1978, 1980; Woolf 1993) have also been identified along the Peace River Valley. These deposits, such as glacial-lacustrine, glacial lake (clay, silt, and sand) veneers, appear as blankets draped over till. Interglacial river deposits, from the last glaciations (the Wisconsin Glaciation) dominate the current landscape (Blyth 2008).

Quaternary fossils could be obtained from a variety of aged sediments. Pre-glacial fossils could occur both in the original deposits and could also be reworked into postglacial gravel fills (Hills and Wilson 2003), requiring a cautious taphonomic assessment as to whether the fossils are *in situ* or reworked. Interestingly, most Quaternary fossil material has been discovered by accident in the course of excavations for gravel pits or other landscape modifications, rather than systematic palaeontological exploration (Wilson 2009). This could be due to the lack of direct palaeontological attention given to exploration of Quaternary sediments in the region. These types of deposits are known to yield tooth and skeletal elements of mammoths, bison, bighorn sheep, rodents, rabbits and birds, as well as gastropods, charcoal, wood, and pollen.

Quaternary sediments, such as fossiliferous moraines, drape across the Cretaceous bedrock especially on the slopes of Portage Mountain and south of Finlay Forks (Rutter, et al. 1972; Harington 2003). Quaternary sediments also occur along the southeast margin of the West Pine Quarry as a terraced palaeo-floodplain at the base of Mount LeMoray. Besides the gravel point bars, which occur at the meanders in the Pine River, the slopes could have exposed draped Quaternary sediments.

4.2.1.3 Geological Strata and Known Palaeontological Resources

Background research identified the geological strata described above as being potentially fossiliferous and present within the LAA. Information accessed from various data repositories is compiled into a table that shows which types of fossils and species are represented in each geological stratum that occurs in the LAA and beyond. These identifications are broken down by invertebrates, vertebrates, and plants. Entries in the table are coded to show where specific taxa are known to occur, whether they are known within the LAA, in close proximity to the LAA, regionally, or in distant regions. The table is organized opposite to the text descriptions above (youngest layers on top) to reflect standard professional palaeontological practice and can be found in Appendix D.

4.2.1.4 Map Review and Palaeontological Potential Model

High-density, georeferenced digital aerial photographs and LiDAR hill-shade imagery of the LAA were reviewed alongside the location of known palaeontological sites and locations of potentially fossiliferous strata as determined through the background literature review to create a palaeontology potential model. As the LAA became better-defined, the palaeontology potential model was expanded and, where necessary, contracted to specifically address areas of palaeontological potential in the locations added or removed from the LAA over time.

Considering the ubiquitous nature of potentially fossiliferous bedrock and sediments throughout the LAA, the map review identified and ranked palaeontological sensitivity areas based primarily on locations where known palaeontological resources were likely to occur in the LAA. This also includes locations with exposed bedrock outcrops, areas with obscured imagery (e.g., shadows) thought to contain bedrock outcrops or Quaternary sediment profiles, and gravel bars along the margins of the watercourses in the LAA. A review of defined palaeontological sensitivity areas is summarized into Table 4.2 below along with an explanation of how field observations have altered the initial perceived degree of sensitivity and how this relates to the efficacy of the palaeontological potential model.

For localities identified as exhibiting palaeontological sensitivity, a tiered system of field survey was recommended. The level of scrutiny for each type of palaeontological sensitivity area identified is provided below.

- Extreme Sensitivity (Purple) – Detailed in-field assessment to ground-truth known palaeontological resources and document fossil occurrences, where present
- High Sensitivity (Red) – Detailed in-field assessment to review exposures of potentially fossiliferous bedrock and sediments and to document fossil occurrences, where present
- Medium Sensitivity (Orange) – Field reconnaissance consisting of a reconnaissance by boat, truck, or helicopter to determine whether closer palaeontological examination or upgrading of preliminary sensitivity assessments was warranted
- Moderate Sensitivity (Yellow) – A brief field reconnaissance if fossil materials were identified or encountered by others during field work. Otherwise, where convenient, a reconnaissance by boat, truck, or helicopter to determine whether closer palaeontological examination or upgrading of preliminary sensitivity assessments was warranted
- Negligible Sensitivity (Blue) – Locations initially identified as Extreme, High, Medium, and Moderate sensitivity that were inspected in the field and found to be void of fossils or locations with exposures having low palaeontological prospection value

Within and adjacent to the LAA, 1127 palaeontological sensitivity areas corresponding to potentially fossiliferous bedrock and sediment exposures were identified during pre-field studies (Golder and AMEC 2011; Golder and Branta 2012), field work, and as part of a preliminary scoping exercise related areas added to the LAA in 2012. Of the 1127 palaeontological sensitivity areas 222 are identified as Extreme, 218 are identified as High, 219 are Medium, 214 are Moderate, and 254 are considered Negligible. In addition, the original palaeontological sensitivity areas defined during pre-field studies were adjusted to better represent observed conditions after 2011 field work.

Upon completion of 2012 field work, once the LAA was better defined, a number of the defined palaeontological sensitivity areas were found to be located beyond the LAA. Currently, there are 899 palaeontological sensitivity areas that overlap with the LAA (211 Extreme, 113 High, 160 Medium, 184 Moderate, and 231 Negligible). These locations include potentially fossiliferous bedrock and sediment exposures located at canyon and coulee walls, terrace edges, and stream meander cutbanks, the superimposed blanket of Quaternary glacial and post-glacial sediments, and the alluvial sediments in gravel banks and terraces.

In addition to the development of palaeontological sensitivity polygons, the resulting potential model was overlain on maps showing private property access considerations. Requests were made by BC Hydro to access private property and leased lands, and denial of access by property owners and tenants limited the palaeontological field assessment in some locations. Portions of the LAA were not defined sufficiently to initiate field studies prior to the 2012 field season (e.g., Portage Mountain Quarry, Dam and Generating Station) and although these areas were subject to a preliminary desk-top scoping exercise to locate exposures favorable for palaeontological prospection, the identified palaeontological sensitivity areas that overlap these portions of the LAA were not reviewed in the field. However, these preliminarily identified palaeontological sensitivity areas are included in the total sum presented above. Palaeontological sensitivity areas located on accessible private land and Crown land were assessed according to the above, where the LAA was sufficiently defined and safety permitted.

4.2.1.5 Assessment of the Palaeontological Potential Model

The palaeontological potential model, as defined during background research (Golder and AMEC 2011; Golder and Branta 2011), has proven to be a reliable estimation of the potential to discover palaeontological resources.

To evaluate the efficacy of the potential model, 2011 field work results were analyzed in relation to the predicted palaeontological potential ratings at each location reviewed. Three percentage values are calculated to express the precision of the pre-field palaeontological potential determinations and are presented in Table 4.2. The "Tier Accuracy" column denotes the percentage of the palaeontological sensitivity areas that maintain their previous sensitivity assessment. The "Collective Accuracy" column indicates the percentage of palaeontological sensitivity areas that retained their original sensitivity assessment or were upgraded to a higher level of sensitivity. The "Resource Capture Accuracy" column indicates the ability to predict the discovery of palaeontological resources by denoting the percentage of palaeontological sensitivity areas in which fossils were observed.

Table 4.2: Pre-field palaeontological sensitivity model tested against 2011 field work results

Sensitivity Ratings	No. Inspected Polygons	Extreme	High	Medium	Moderate	Negligible	Collective accuracy	Tier Accuracy	Resource Capture Accuracy
Extreme	21	20	0	0	0	1	95%	95%	95%
High	45	34	5	2	3	1	87%	11%	76%
Medium	45	21	2	13	1	8	80%	29%	47%
Moderate	2	0	0	1	1	0	100%	50%	0%
New	24	18	3	2	1	0	N/A	N/A	75%

4.2.1.5.1 Palaeontological Potential Model Accuracy

Palaeontological sensitivity areas assessed as having extreme sensitivity were almost entirely accurate. Fossils were observed in 20 out of 21 extreme sensitivity locations (95%) that were surveyed. Often, similar assemblages were recorded to those reported previously documented.

The high sensitivity predictive category was a good predictor of fossil presence. Fossils were observed in 34 out of 45 high sensitivity locations (76%) that were surveyed. A further five high sensitivity locations (11%) that have maintained their tier accuracy are suggested to have the potential to find fossils, given additional exploration, resulting in a potential collective accuracy of 87%. Often, the fossil assemblages discovered in these locations contained new discoveries and thus offer important contributions to the local palaeontological inventory.

For the medium and moderate tiers of palaeontological sensitive areas, field screening tended to focus on more favourable locations for detailed survey. However, the "Resource Capture" accuracy of the surveyed medium palaeontological sensitivity areas (47%) indicates the importance of identifying this tier of potential as it provides a broad net to capture the potentially fossiliferous bedrock and sediment exposures likely to be concealed by shadows or unfavorable photograph angles present in aerial photography.

4.2.2 Field Assessment Results

Palaeontological field work was conducted in 2011 and 2012 by two crews comprised of a senior palaeontologist and an assistant. Field work focussed on detailed assessment of identified extreme and high palaeontological sensitivity areas located within and adjacent to the Project components associated with the Peace River valley including the proposed transmission system. In addition, several medium and moderate palaeontological sensitivity areas were reviewed in detail. Less defined portions of the LAA and components that are situated beyond the Peace River valley (e.g., Portage Mountain Quarry and West Pine Quarry) along with private properties within the LAA where access was not granted, remain to be assessed.

During 2011 field studies a total of 137 palaeontological sensitivity areas were assessed including 21 extreme, 45 high, 45 medium, two moderate, and an additional 25 locations that were added to the original palaeontological potential model. Of the 25 newly added locations, 18 are identified as extreme because they were observed to contain fossils, three are high, three are medium, and one is moderate. Over two years of field study, 609 palaeontological sensitivity areas were assessed, resulting in the identification of 211 positive palaeontological sensitivity areas. Based on close proximity and similarity of palaeontological contents observed in some positive palaeontological sensitivity areas, several locations were merged to reduce redundancy in reporting and to provide a more accurate spatial representation of the extent of observed fossil occurrences. Merging some of the positive palaeontological sensitivity areas resulted in a total of 187 individual positive locations including 41 previously recorded sites and two chance find locations that are determined to be negligible. In total 173 positive palaeontological sensitivity areas are situated within the LAA (Figures 4.7 and 4.8.1 to 4.8.32).

Table 4.3 details each type of palaeontological sensitivity area and shows the types of field assessments undertaken, and is based on the unmerged, revised palaeontological sensitivity area rankings. Detailed descriptions of positive palaeontological sensitivity areas after being merged, including those occurring beyond the LAA, are provided in Appendix E.

Table 4.3. Summary of LAA palaeontological sensitivity areas and field assessment methods

Assessment Method	Extreme	High	Medium	Moderate	Negligible	Totals
Inspected	192	4	14	7	70	**287**
Viewed Close	9	18	26	54	74	**181**
Viewed Afar	4	7	20	45	65	**141**
Not Assessed	6	84	100	78	22	**290**
Totals	**211**	**113**	**160**	**184**	**231**	**899**

In relation to the first column of the table above, “inspected” palaeontological sensitivity areas are those locations where pedestrian survey was conducted to determine if fossils were present; these locations have the highest degree of certainty attached to the result. Palaeontological sensitivity areas “viewed close” are those locations inspected by boat or where proxy locations (e.g., locations directly across the river from one another) were used to determine if fossils are present. Locations “viewed afar” are those palaeontological sensitivity areas that had limited access because of safety concerns or were viewed from the boat and determined to be of low palaeontological value (e.g., areas with only potential to find *ex situ* fossils). Locations that were “not assessed”

include those palaeontological sensitivity areas that were identified as proxy locations for exposures occurring in the LAA, portions of the LAA not assessed yet, and locations where access permissions could not be obtained in time for field work.

A sample of fossils was collected from several of the positive palaeontological sensitivity areas. Specimen sampling was limited by several factors including size, weight, and safety considerations balanced with the need to obtain a small representative sample and to salvage significant fossils in danger of damage or removal. Fossils were collected in accordance with the guidance provided in the *Fossil Management Plan for British Columbia* (Fossil Management Review Technical Working Group 2004) which defines good practices for specimen collection for non-scientific purposes. In addition, some specimens were collected that are thought to be of scientific importance or required closer scrutiny in a controlled setting. During field work, 285 individual fossil specimens were acquired from 104 palaeontological sensitivity areas at 190 individual way point locations. These specimens represent a variety of taxa that includes plant and animal species and trace fossils from various geological stratigraphic units that occur throughout the LAA.

The geological stratigraphic units that occur in the LAA have been broken down into the following eleven complexes to provide a mechanism to determine an appropriate method for achieving a representative sample of palaeontological resources in the LAA during mitigation. The eleven complexes are defined as follows:

1) North Dam Upper Shaftesbury Fossil Complex
2) Moberly River Upper Shaftesbury Fossil Complex
3) Tea Creek Confluence Middle to Upper Shaftesbury Fossil Complex
4) Wilder Creek Middle to Upper Shaftesbury Fossil Complex
5) Cache Creek Middle to Upper Shaftesbury Fossil Complex
6) Halfway River Lower to Middle Shaftesbury Fossil Complex
7) Gates Island Gates - Hulcross - Shaftesbury Fossil Complex
8) Lynx Creek Gates Fossil Complex
9) Hudson’s Hope Moosebar - Gates Fossil Complex
10) Upper Maurice Creek Cruiser Complex
11) Quaternary Complex

5.0 ARCHAEOLOGY

The following sections describe the methods and results of the archaeological assessment. The results of the assessment are presented in Section 5.2.

5.1 Archaeological Methods

This section describes the methods for the archaeological literature review, overview assessments, field program, data collection, recording, and analysis. Prior to field work, existing information was reviewed, as described in Section 5.1.1. The field sampling program used a predictive model, which is described in Section 5.1.2. Certain locations could not be assessed in the field due to access restrictions or incomplete design plans at the time of the assessment. These locations were assessed at an overview level, as described in Section 5.1.3 and Figure 5.1. Section 5.1.4 outlines the general approach that guided the field methods that follow in Section 5.1.5. Post-field activities involved the description and analysis of archaeological materials collected during the field program. These methods are described in Sections 5.1.5.1 through 5.1.5.15.

5.1.1 Review of Existing Information

A review of existing information was conducted to characterize the archaeological baseline for the Project and to identify data gaps. Due to the limited amount of existing archaeological information within the LAA, it was necessary to extend the document review to the broader Peace region to adequately evaluate site distribution patterns. In this context, the Peace region is defined as those British Columbia lands east of the Rocky Mountain Trench within the National Topographic System 93O – 93P – 94A – 94B map areas (mainly in the “GR” and “HR” Borden blocks). Adjoining parts of northern Alberta within the “GQ” “HQ” Borden blocks are included in the counts of archaeological sites and summaries of previous investigations. These parameters largely define lands drained by the Peace River to the east of the Rocky Mountains. Some additional British Columbia archaeological sites from outside the Peace region were included in the review, to encompass those few northeastern British Columbia archaeological sites where scientific or mitigative excavations have taken place. Figure 5.3 shows the area that was encompassed by the existing information review.

Geo-spatial coordinates for documented archaeological sites within the Peace region were obtained from the Provincial Heritage Register. This information, including site distribution maps and an orthophoto layer, is available via the Remote Access to Archaeological Data (RAAD) online application. Comparable data on archaeological site distribution in the Peace District of Alberta were obtained from Alberta Culture and are available in the Alberta Archaeological Site Inventory.

5.1.2 Archaeological Predictive Modeling

Predictive models in archaeology identify lands that have a greater potential to contain archaeological remains than lands selected randomly. These models use environmental and cultural variables to rank the landscape in terms of relative predicted site potential. Most models use mapped environmental variables (e.g., slope, slope direction, vegetation classes, soil types, distance to various water bodies, and trails) to predict archaeological site potential.

Existing archaeological data suggest that archaeological sites in northeastern British Columbia tend to be located on topographic landforms such as knolls, hummocks, small ridges, terraces, linear summit terrain, and slope breaks. These landforms can range from very small, ill-defined features (e.g., hummocks only a few metres across and standing less than 1 m above surrounding terrain) to extensive landforms such as Rocky Mountain ridgelines that may form a single, high potential area tens of kilometres long. The accuracy and precision of LiDAR allows for computer recognition of landforms as small as 5 m by 10 m in size.

In 2010, Millennia Research Ltd. (Millennia), at the request of BC Hydro, created a GIS-based predictive model for the heritage resources LAA, using LiDAR base data supplemented by surficial geology mapping and data taken from British Columbia Terrain Resource Information Mapping (TRIM) and Oil and Gas Commission (OGC) maps (Millennia 2010a, 2010b). LiDAR is a remote sensing technology that provides accurate three-dimensional maps to reveal micro-topography otherwise hidden by vegetation. The modeling process began with an examination of hillshaded LiDAR data that provided a view of the ground as it would appear without vegetation. Landforms exhibiting qualities associated with known, or suspected, high archaeological potential were identified by a unique set of characteristics or variables. Each landform type considered to have high archaeological potential was checked to determine if the model was adequately capturing the landform, and adjustments were made as necessary.

Anthropogenic (human-made) landforms and disturbance areas (e.g., aggregate quarries and roads) were removed from areas modelled as high potential. Similarly, water bodies, which were also occasionally modelled as having high potential, were removed. High potential polygons from recent islands in the Peace River channel were also eliminated from the model since their formation post-dates archaeological occupation of the valley.

Many small, level benches occurring partway down bluffs, slides, and other unstable landforms were captured as areas of archaeological potential in the initial model run. It was concluded that all such landforms had low potential and that these were “false” areas of archaeological potential. The initial solution to this issue was to eliminate all such unstable landforms from the modeled areas of high potential. However, examination of the LiDAR hillshade maps revealed that a number of documented archaeological sites occur on old slide deposits. Therefore, only flat areas within distinctively steep, relatively recent, bluff landforms were removed from the model.

The transmission line and some parts of the dam and generating station are located outside of the Peace River valley, and these plateau lands required a modified archaeological potential model. The model as applied to these plateau lands employed the same principles as the predictive model currently used for archaeological work on the plateau in the Peace River Forest District (Eldridge, et al. 2010), except with more accurate LiDAR base mapping. The plateau model identifies all micro-topographic features regardless of their elevation. The transmission line will cross a variety of terrain features, with some areas characterized by numerous hummocks with high potential, and other areas where the land is mostly flat. The model typically classifies these large flat areas as having low potential, but they may contain some areas of moderate and high potential (Millennia 2010b).

The valley and plateau models were checked against known archaeological site locations to evaluate their performance. Provincial standards require that a high percentage of the known sites are “captured” by the model, while the overall amount of land area captured as high potential is relatively small (BC Archaeology Branch 2009a). Ground truthing methods used to assess the Site C model performance are presented in Section 5.1.5.1.

5.1.3 Archaeological Overview Assessment of Selected Areas

A number of project components were subject to an archaeological overview assessment (AOA) as development plans were not adequately advanced in those areas to allow for a thorough archaeological assessment. These areas are the as yet undefined construction activity areas adjacent to the dam site ("dam site adjacent construction areas") (2,040 ha), Wuthrich Quarry (18 ha), West Pine Quarry (104 ha), Portage Mountain Quarry (148 ha), Del Rio Pit (135 ha), and Area E (80 ha) (Figure 5.1). This AOA does not include some access roads, unless captured under other project components (e.g., original dam site footprint), a transmission line tie-in at Peace Canyon Dam Generating Station, and a potential aggregate source located within the reservoir but above the inundation zone.

The purpose of the AOA was to summarize previous archaeological work and known archaeological resources in the development areas mentioned above, assess their archaeological potential, and provide recommendations for further archaeological work that may be required prior to development of those areas.

The AOA consisted of two main tasks: 1) a desktop review of available archaeological data; and, 2) application of the Millennia Research (2010a, 2010b) Site C Clean Energy Project archaeological predictive model to identify areas of low, moderate, and high archaeological potential. For the desktop review, the Provincial Heritage Register was accessed to obtain information on previously recorded heritage sites within each of the project components. Readily available reports on the archaeology of each project component, and adjacent areas, were reviewed in concert with detailed project component maps. With respect to the Millennia Research (2010a, 2010b) Site C Clean Energy Project archaeological potential model, its application was limited to those areas with LiDAR coverage, resulting in small model coverage gaps in the West Pine and Portage Mountain Quarries. For these areas which lack model coverage, archaeological potential values (low, moderate, or high) were extrapolated from the portion of the project component that includes model coverage. The extrapolation assumes that a similar distribution of low, moderate, and high archaeological potential exists within the data gap areas as the rest of the development area.

The results of the review of existing information and the application of the archaeological predictive model were synthesized to provide a statement on what is known about archaeological resources in each project component, its archaeological potential (sensitivity), and recommendations for further archaeological work.

5.1.4 Approach to the Archaeological Field Program

The main objective of the archaeological field program was to characterize the nature of the archaeological resources in the LAA so that potential project effects could be assessed and appropriately mitigated. Data from the field program, combined with the results of previous archaeological surveys for the Project (e.g., Spurling 1980a), were used to obtain information on the content, size, age, density, and distribution of archaeological sites in the LAA.

Given the area involved, it was not possible to examine all lands within the LAA. Instead, the field program focused on sampling locations predicted to have the highest potential for large sites, complex (e.g., stratified) sites, and the greatest density and variety of archaeological materials. These areas of high archaeological potential were identified and mapped using the predictive model, then inspected in the field, except where access to private property was not granted. Areas of lower predicted potential also were inspected, but received less intensive coverage. This type of stratified sampling approach is a common in archaeological assessments of large areas, and is consistent with the methods described in the Heritage Inspection Permit application.

The model classifies the LAA into polygons of low, moderate, and high predicted archaeological potential. An analysis of previous survey data collected by Simon Fraser University and the Golder team showed that archaeological resources tend to consist of relatively small clusters of cultural material with low densities in most portions of the LAA. Archaeological sites defined by previous studies usually consisted of one or more clusters. Large sites generally consisted of multiple, often overlapping, artifact clusters. The predictive model that guided the field work modeled lands where larger sites are present, as well as lands with greater numbers of smaller sites, as having high archaeological potential. Lands modeled as moderate or low potential were predicted to have both lower frequencies of archaeological sites and sites with lower artifact densities.

The field program focused on areas modeled as having high archaeological potential. The field program was concerned with relocating and documenting previously recorded archaeological sites as well as locating and documenting unknown archaeological sites. Both systematic and judgemental field methods were used in this inventory.

High Potential Lands

The model predicted that approximately 617 ha of land within the heritage resource LAA has high archaeological potential. In these areas, the following methods were utilized, as detailed in Section 5.1.5.1:

- Systematic survey (i.e., grid testing and surface inspection)
- Adaptive testing where sites were found
- Evaluative testing at selected sites
- Systematic surface inspection in cultivated fields with surface exposure
- Judgemental survey (primarily subsurface testing)

Although systematic survey was the primary method used to identify new archaeological sites on lands of high archaeological potential, judgemental testing was also used to test between negative systematic grid tests or near a positive grid test that was surrounded by negative adaptive and grid tests.

Low and Moderate Potential Lands

Areas modelled with low and moderate archaeological potential were also investigated for surface or subsurface archaeological remains. On lands identified by the model as having low or moderate archaeological potential, the following methods were used, as described in Section 5.1.5.1:

- Judgemental survey (i.e., surface inspection and subsurface testing)
- Systematic surface inspection in cultivated fields with surface exposure
- Adaptive testing where sites were found
- Evaluative testing of selected sites

Surface inspections were conducted on low or moderate potential lands located near or en route to high potential lands or previously recorded sites. Judgemental subsurface testing was conducted in these locations if field observations suggested unmodeled high potential. Accessible cultivated fields with good surface exposure were subject to systematic surface inspections; these fields typically contained large areas of low and moderate potential lands.

Other Investigations

Other settings with archaeological potential were incorporated into the field program. These included:

- Well-defined terrestrial margins of wetlands
- The saturated side of wetland margins
- Small (≤100 m^2), well-defined landforms
- Lands peripheral to the historical fur-trade post of Rocky Mountain Fort

The rationale for including these settings in the field program, as well as the method which were used, are provided in Section 5.1.5.10.

5.1.5 Archaeological Field Methods

Field surveys took place in the summer and fall of 2010, 2011, and 2012. All work was carried out under snow-free and unfrozen ground conditions. The 2010 field investigations focused on testing the predictive model, and subsequent field work inventoried the remainder of the LAA, with the exception of limited areas that are yet to be investigated.

5.1.5.1 Model Ground Truthing

Evaluation of the predictive model included testing on lands rated as having low, moderate, and high archaeological potential within the reservoir and dam site. Prior to starting field work, a few properties in the valley were identified as unavailable due to access issues, and the model testing was designed to avoid these lands. Encumbered Crown land for which access permission had not been obtained was also excluded from the model testing field work. No discernible bias could be identified from the exclusion of these lands, and all environmental settings are well represented in the sample. Moreover, Site C archaeological inventory data from the Simon Fraser University (SFU) judgemental and probabilistic assessments in the 1970s and 1980s provided reliable data on these lands that could be used during the analysis to further avoid bias in the sample.

Ground truthing involved systematic ground surface inspection and subsurface testing at predetermined locations within a series of 30 metre wide survey transects. The objective of ground truthing was to confirm the presence or absence of archaeological materials and to assess whether the model correctly identified site potential. Ninety predetermined transects were planned across the reservoir on a north–south grid, at constant intervals measured from an initial location selected at random. Transect length was dependent upon its location within the LAA.

A subsurface test interval of 10 m was adopted for lands rated as exhibiting moderate or high archaeological potential. In low potential settings, a test interval of 100 m was used allowing for systematic testing of all low potential areas with the equivalent number of tests used in the moderate and high potential areas. This approach provided representative samples from areas of assessed low, moderate, and high potential.

Each field crew was equipped with LiDAR hill shade maps, orthophotos, or other suitable maps, and identified their assigned survey location using a programed Trimble Nomad Global Positioning System (GPS) receiver with a ProXT external receiver. Crews used GPS units that were preloaded with model predictions, survey transects, and subsurface test locations within those transects. Survey transects were covered on foot, with crew members spaced at a constant interval of 10 m. Each transect consisted of three survey lines spaced 10 m apart. The surface was inspected for archaeological evidence such as artifacts, fire-altered rocks, features such as cultural depressions and culturally modified trees, and historical remains.

Archaeological survey data were recorded using GPS receivers, or in field notes whenever satellite coverage was unavailable. Test locations were identified using GPS receivers as well as by compass-and-chain. Subsurface test locations, field observations, assessment of archaeological potential, sediment layer descriptions, and test results (i.e., positive or negative) were recorded on the GPS receivers or in field notes. Detailed information included, but was not limited to, the following categories:

- Terrain description
- Archaeological potential assessment (or reassessment)
- Location, description and, if appropriate, measured attributes of surface finds and features
- Subsurface test log; and 5) photograph log

Archaeological potential was reassessed in the field, using well-established criteria appropriate for this region such as surface integrity, distance from aquatic features, presence of landforms elevated above surrounding terrain, forest cover, slope and aspect, soil drainage qualities, and the proximity of trails or known archaeological and historical heritage sites. Where the in-field assessment of archaeological potential varied from the modeled potential, the discrepancy was noted as well as the rationale for its reassessment. The discrepancies between the potential model and assessed potential were recorded and used for the ongoing evaluation of the GIS model.

Tests were excavated manually using shovels. Subsurface tests measured approximately 35 cm by 35 cm to 40 cm by 40 cm, and were typically excavated to a depth of about 50 cm (Appendix N-2, Photograph 1). Tests were rarely dug deeper, as 90% of the cultural material located by the SFU quadrats was within 50 cm of the surface.

Sediments from the tests were screened through 6 mm (¼ inch) mesh, except where sediment characteristics (e.g., particle size, organic and inorganic inclusions) and ground moisture prevented effective use of screens (Appendix N-2, Photograph 2). When screening was not possible, manual sorting with a trowel was employed. All tests were backfilled upon completion. Any artifacts and other archaeological materials encountered during the testing were collected.

The leader of each crew observed and recorded the depth of each shovel test before it was backfilled. This information was recorded on hand-held data loggers or in written field notes. A database was created that includes the depth of all shovel tests. The database also includes information on test locations that could not be excavated ("No Tests") due to adverse environmental conditions (e.g., waterlogged sediments, subsurface boulders, steep slopes). Further quality review was provided by senior archaeologists who joined crews in the field to monitor work practices and compliance with the proposed methodology.

5.1.5.2 Archaeological Inventory

As mentioned above, several site discovery methods were used:

- Systematic survey with subsurface testing
- Judgemental survey (with optional judgemental subsurface testing)
- Systematic surface inspection (without subsurface testing)
- Systematic surface inspection

Deep testing was used at locations with potential for deeply buried archaeological remains. Two other methods, adaptive testing and evaluative testing, were used to obtain additional information about archaeological sites after they had been located. Each method is discussed separately in the sections that follow.

Regardless of method, field crews were equipped with LiDAR hillshade maps, orthophoto maps or other suitable maps, and identified their assigned survey location using a programed Trimble Nomad GPS data logger with a ProXT external receiver (Appendix N-2, Photograph 3). The Trimble units were preloaded with archaeological potential data and systematic (grid) subsurface test locations. Crews were also outfitted with Garmin GPS units preloaded with grid test locations as a backup to the Trimble units.

Areas to be surveyed were accessed by truck, all-terrain vehicle, boat (Appendix N-2, Photograph 4), and on foot. Survey coverage was organized by property parcel where applicable. A visual inspection was conducted to look for artifacts, fire-altered rock, cultural depressions, culturally modified trees, and other archaeological materials, as well as historical refuse and features for the historical resources assessment and fossils for the paleontological assessment.

5.1.5.3 Systematic Survey with Subsurface Testing

This site discovery method combined systematic surface inspection with systematic subsurface testing, and was used in areas identified by the predictive model as having high archaeological potential. The purpose of the systematic survey was to locate and delineate archaeological resources.

Prior to field work, a GIS was used to place a 12 m grid over all polygons of modeled high archaeological potential. The grid was oriented along the cardinal directions. Test pit locations were then positioned at the grid line intersections, i.e., every 12 m.

During the systematic survey, crew members were spaced at 12 m intervals and moved from grid test to grid test, inspecting the ground surface while moving between tests. The grid tests were located using preloaded test locations in the Trimble GPS, or by combination of Garmin GPS and compass-and-chain when satellite coverage was unavailable for the more sensitive Trimble units. Subsurface tests (called grid tests) were dug, when not prevented by large surface rocks, trees, or other constraints, at each grid intersection.

Tests were dug by hand with a shovel, with a typical test measuring 35 cm by 35 cm. Tests were excavated to a depth of about 50 cm (the effective reach of a shovel), or until they reached sterile non-archaeological sediments or impediments such as boulders or layers of river cobbles. Sediments from the tests were screened through 6 mm mesh except where a combination of sediment characteristics (particle size, organic and inorganic inclusions, etc.) and ground moisture prevented the effective use of 6 mm mesh screens (e.g., wet sediments with high clay content). When screening was not possible, manual sorting with a trowel was employed. Each grid test was excavated and left open for quality control inspection and documentation by the Crew Lead. After the Crew Lead was finished, the test was backfilled and restored as close as possible to its original condition. Artifacts and other archaeological materials encountered during testing were collected.

5.1.5.4 Systematic Surface Inspection

Systematic surface inspection was the primary method used to locate archaeological sites in cultivated or fallow fields with good ground exposure, as well as in other locations with good surface exposure (e.g., deflated soils) or disturbance (Appendix N-2, Photograph 5). BC Hydro provided information on the location and ownership of cultivated fields in the LAA and arranged for access to these properties, where possible.

Compared with subsurface testing, systematic inspection of an exposed soil surface often provides a superior understanding of the extent of archaeological remains, where present, as well as the density and diversity of cultural materials. Exposures were situated on landforms with low, moderate, and high archaeological potential.

Survey areas were examined on foot, with crew members spaced at an interval of either 5 or 10 m. The surface was inspected for artifacts, faunal remains, fire-altered rock, historical artifacts, fossil remains and other heritage objects. Prescribed tillage with a plough, cultivator, or harrow to increase visibility in previously cultivated fields was considered but not used due to a lack of opportunity. Surface inspection was followed by adaptive testing where surface artifacts were encountered. Where possible, adaptive testing followed the same procedures that were used in other settings. In fields with high artifact density (where surface artifacts are spaced less than 5 m apart), adaptive testing was limited to the outer perimeter of the artifact scatter, reduced in frequency, or replaced by other forms of subsurface testing (e.g., judgemental testing or evaluative testing).

Where the ground cover in fallow fields or pastures prevented effective surface inspection, another method such as systematic or judgemental survey with subsurface testing was used.

5.1.5.5 Judgemental Survey

Surface inspection of judgementally selected locations, either with or without subsurface testing, was employed in addition to systematic survey at the discretion of the field crew in all parts of the heritage resources LAA. Judgemental survey allowed Crew Leads to use their experience and expertise to select locations for investigation not selected by other methods (e.g., predictive model or systematic survey).

Judgemental survey was the primary method used in moderate and low potential areas to identify both previously recorded and new archaeological sites. For previously recorded sites, site records were used to guide the crew to the approximate site location. The area was then examined for surface artifacts or other archaeological evidence. If present, adaptive testing was initiated around the surface finds. If not present, judgemental or systematic testing was initiated. At times, subsurface testing was not initiated due to the surface survey results (e.g., inundated ground surface), or where lands were not available for subsurface testing due to recently seeded fields or fields still in crop. For sites on large landforms, systematic testing at a 10 or 12 m interval was commonly used, whereas judgemental testing at variable, smaller intervals was commonly used on small landforms.

A concerted effort was made to identify new archaeological sites through judgemental survey in areas of moderate and low potential. Recent high-resolution orthophotography and small-scale maps were consulted to identify locations with potential for surface exposures that could be judgementally inspected for archaeological evidence. These locations included road edges, ditches, deflated areas, eroding terrace edges, and eroding stream banks. Exposed areas observed in the field, usually during transit to and from high potential areas, were also inspected. Judgemental shovel testing was used to augment surface inspection where, in the opinion of the field Crew Lead, there was potential for buried archaeological remains.

Judgemental survey with systematic testing at 10 m intervals was used to test for Aboriginal encampments around Rocky Mountain Fort. This specific application of judgemental survey is described in Section 5.1.5.5.

Except for the selection process, the techniques used during judgemental survey (surface inspection, subsurface testing, and data recording) were the same as those used during systematic survey (described above). When subsurface testing was part of judgemental survey, testing occurred at irregular intervals or on a grid, at the discretion of the field crew. Adaptive testing took place around positive judgemental tests to gain additional information about the sites. The location of judgementally surveyed areas was recorded in the Trimble GPS units.

5.1.5.6 Adaptive Testing

Adaptive testing involved the excavation of subsurface tests at closely spaced intervals around a positive subsurface test or surface artifact find, and was explicitly designed to sample clustered phenomena. The purpose of the adaptive testing was to refine the location of site boundaries and to provide a better understanding of the nature of the sites than could be achieved strictly through grid testing. Given the clustered nature of archaeological resources, adaptive sampling was the most effective and efficient method for collecting a large sample of archaeological materials and for characterizing a site.

Adaptive sampling involved the excavation of shovel tests on a 2 m interval, radiating out from a positive shovel test or surface find in cardinal and inter-cardinal directions (Figure 5.2; Appendix N-2, Photograph 6). Eight tests were dug around each positive test or surface find. In some instances, such as areas with dense artifact concentrations or very small landforms, only four tests were excavated. If an adaptive test was positive, adaptive sampling was continued from the positive test, and continued until no further positive tests were encountered.

In ploughed fields or locations with high surface artifact density, adaptive testing was restricted to the outer perimeter of the artifact scatter, reduced in frequency, or replaced by other forms of subsurface testing (e.g., judgemental testing, evaluative testing) at the discretion of the Crew Lead.

5.1.5.7 Evaluative Testing

Evaluative tests were placed judgementally to recover additional information where shovel testing was considered insufficient for assessment. Evaluative testing involved the controlled excavation of test pits measuring 50 by 50 cm or 100 by 100 cm, excavated in 10 cm arbitrary levels to a basal, non-archaeological matrix (Appendix N-2, Photograph 7). Soils from evaluative tests were screened through 6 mm mesh.

Artifacts found in evaluative tests were treated like those found in subsurface tests, as described above. Once completed, units were photographed and wall profiles were prepared, except where there was no discernible stratigraphy. Where there was no discernible stratigraphy, the walls were photographed to document the rationale for not preparing wall profiles.

5.1.5.8 Previously Recorded Archaeological Sites

As the majority of archaeological studies in the LAA were completed over 30 years ago, the field program revisited and updated the documentation for previously recorded archaeological sites. Prior to this study, 116 archaeological sites had been recorded within the LAA. Site revisits included a review of existing site documentation, followed by a surface inspection and systematic or judgemental testing to confirm the location and to locate additional archaeological materials attributable to that site. Where new information was obtained, site form updates have been, or will be, submitted to the BC Archaeology Branch for inclusion in the Provincial Heritage Register.

5.1.5.9 Deep Testing

Deeply buried archaeological sites have the potential to be highly significant because of their possible antiquity, superior preservation of cultural materials, and potential for stratified occupational layers. These sites are rare in northeastern British Columbia and important archaeologically, especially for the development of regional chronologies. These locations generally correlate to specific geomorphic situations, notably stabilized, ancient sand dunes (including swales between dune crests), alluvial fans, and lands buried by landslides.

The purpose of the deep testing strategy was to explore settings with significant accumulations of sediments, in which archaeological remains could be buried at depths greater than could be reached during standard subsurface testing. Alluvial fans and features interpreted as dune fields using LiDAR mapping were recommended targets for this testing, including dune fields near the concentration of archaeological sites at the Watson Slough locality (Appendix N-2, Photographs 8-12).

A two-stage approach to identify landforms suitable for the preservation of deeply buried deposits was implemented. Stage one consisted of the hand excavation of deep shovel tests and, where possible, continuation of the shovel tests using a 10 cm diameter bucket auger. Where deep deposits with archaeological

materials were identified, or where the observed stratigraphy suggested that deeply buried archaeological sites may be present, mechanically assisted trenching was used to further investigate these landforms (stage two). Auger tests were dug with a 10 cm diameter hand auger, to the effective reach of the tool, between 2 and 4 m below surface. Sediments were removed and recorded in approximately 20 cm intervals, and screened through a 6 mm mesh; a plastic tarp was used to collect the back dirt, all which was returned to the original excavation. Stratigraphic details were recorded for each test.

A small rubber-tracked excavator with a 90 cm wide smooth "clean out" bucket was employed to excavate trenches. Trenches measured approximately 1 m wide by approximately 2.3 to 2.6 m in length, and were excavated to inferred sterile deposits, or the reach of the excavator, approximately 1.9 to 2.3 m in depth. Attempts were made to excavate each trench in 20 cm lifts, although the excavation of deeper sediments was more challenging and occasionally resulted in lifts up to 35 cm thick. Removed sediments were segregated by lift onto small tarps. A sample (approximately 5%) from each lift was screened through 6 mm metal mesh. In the event that identified archaeological materials were encountered, 100% of the sediments from the respective lift were screened. Notes on the stratigraphy of each trench were taken, along with photographs. Following screening, the sediments were replaced in the trench by lift, in the reverse order of excavation.

5.1.5.10 Other Investigations

Other settings with archaeological potential were incorporated into the field program. These included:

- Well-defined terrestrial margins of wetlands
- The saturated side of wetland margins
- Small (≤100 m^2), well-defined landforms
- Lands peripheral to the historical fur-trade post of Rocky Mountain Fort

5.1.5.10.1 Wetlands

Wetlands are unique environmental features that often contain a diverse range of flora and fauna in a concentrated area. Not only are many of these resources of interest to human populations, but also wildlife. Not surprisingly, this concentration of biological diversity is reflected in the archaeological record through increased site density in these areas (Nicholas 1992, 1998). The margins of wetlands are considered to have high potential for archaeological remains and were evaluated using the systematic, adaptive, and judgemental site investigation methods detailed above

Following discussions with the BC Archaeology Branch, the Golder team also investigated wetland margins in an attempt to locate buried "wet site" deposits. These locations have potential to contain artifacts made from ordinarily perishable organic materials (e.g., hide and sinew, wood) and could provide unique information given that the majority of artifacts recovered from archaeological sites in the area are stone tools and waste pieces discarded during tool manufacture or maintenance.

To evaluate the potential for perishable artifacts to exist in these environments, the margins of wetlands adjacent to two high density lithic artifact scatter sites were targeted with the intent of locating buried wet site deposits.

These locations were selected as high density lithic scatter sites infer a long period of use and higher probability for perishable wet site deposits to be present. A combination of judgementally placed mechanical and hand excavated subsurface tests were excavated in these areas to search for buried perishable materials.

5.1.5.10.2 Small Landforms

Small, discrete landforms with well-defined boundaries are often interpreted by archaeologists in northeastern British Columbia as having high archaeological potential. However, the archaeological potential of these small landforms in the Peace River valley has not been established. This is a gap in our understanding of archaeological site distribution in the development area. To address this gap, small landforms in the LAA were judgementally shovel tested if field observations suggested they had site potential. For this Project, a small landform is defined as less than 100 m^2 in area, surrounded by 30 m or more of undifferentiated level terrain. These landforms are not equivalent to high points in a generally uneven or undulating landscape, nor are they high spots on a ridge or knoll.

Small landforms were modeled as having high potential using the GIS model. Although individual test locations were predetermined, the crews were allowed to deviate and move these tests according to the real-world configuration of the landform. LiDAR mapping used for the GIS model identified 306 localized (≤100 m^2) landscape features elevated above surrounding terrain otherwise modeled as having moderate or low archaeological potential. A cluster of eight systematic tests was programed on each small landform, except for some small landforms that were too small to allow plotting of eight tests. In total, 2,269 were plotted (Appendix N-2, Photograph 13).

5.1.5.10.3 Traditional Land Use Sites

BC Hydro signed agreements with the Treaty 8 Tribal Association, Blueberry, Saulteau, Duncan's, Dene Tha', and Horse Lake First Nations to complete "living memory" TLU studies for their respective areas of interest. First Nations were invited to provide this information early in the program so it could be incorporated into the archaeological assessment. Unfortunately, the reports were not available to the heritage assessment team in time to inform the field program, but were instead reviewed for information relevant to understanding the archaeological and historical assessment results. A summary of the review is presented in Section 3.2.4 of this report.

5.1.5.10.4 Investigations Adjacent to Rocky Mountain Fort

No further archaeological work was conducted within the boundary of Rocky Mountain Fort, as the site has been extensively studied and documented (e.g., Burley, et al. 1996). However, since limited information exists on Aboriginal encampments associated with the fort, the field program included testing in the vicinity of Rocky Mountain Fort to identify possible outlying encampments.

The search for Aboriginal encampments associated with Rocky Mountain Fort relied on judgemental survey including testing of several locations peripheral to the fort, suspected to have been potential locations for Aboriginal encampments. These locations were identified based on a review of the historical literature focusing on traditional Aboriginal activities around the fort, a review of previous archaeological survey and testing in the vicinity of the fort, and a review of topography, drainage, and river bank erosion in the vicinity. Five locations

were identified as potential sites for Aboriginal camps. Each area was then systematically surface inspected and tested at 10 m intervals. Tests were dug and documented using the same procedures as with the systematic grid survey.

The book *The Prophecy of the Swan* (Burley, et al. 1996) provides transcripts of two fur trade journals, one from Rocky Mountain Fort (winter trade season of 1799 – 1800) and the other from St. Johns Fort, downstream from the LAA at the mouth of the Beatton River (winter of 1822 – 1823). Based on these journals, the following observations can be made about Aboriginal encampments:

- Aboriginal people, primarily men, visited Rocky Mountain Fort for a day or two while trading. The journal entries imply that these people were staying at the fort during these visits, but it is not clear if they were staying inside or outside the fort compound (there was no stockade at this fort).
- The staff arrived at Rocky Mountain Fort at the beginning of the year with four women (most likely Aboriginal), five children and 12 men. The women are mentioned occasionally throughout the journal so, by implication, they are either staying in the fort or immediately adjacent.
- One journal entry states: “Part of the Indians came over with all of their things.” This comment implies that some Aboriginal people stayed across the river from Rocky Mountain Fort, but this practice seems to be a rare occurrence as it is only mentioned once. More typically, men arrived alone at the fort after travelling from distant camps.
- Most “hunters” seem to have lived at camps with three to five “lodges” at least one or two days travel from Rocky Mountain Fort. A hunter also lived at the fort.
- At St. Johns, 22 years later and further downstream, some elderly Aboriginal people lived in lodges (for the winter) near the fort. In one case, an elder’s son was a hunter for the fort.

Earlier archaeological work at Rocky Mountain Fort failed to find any evidence of Aboriginal encampments:

> “Despite a continued and intensive search in the area around Rocky Mountain Fort we were unable to locate unequivocal archaeological remains for the encampments of these people [Aboriginal people mentioned in the fort journal]. Whether these camps lay at a distance from the post, or whether they left few or no marks on the landscape, cannot now be determined.” (Burley, et al. 1996:61)

The end of season report for excavations at the fort suggests that Aboriginal encampments may still be found immediately adjacent to the fort compound:

> “While the few shovel test excavations that coincide with these anomalies [magnetic anomalies in an area ca. 35 by 70 m around Rocky Mountain Fort] do indicate they are cultural in origin due to the identification of concentrations of burnt bone, more expansive exposures are needed to determine whether they represent the hearths of outlying native encampments, or Euro-Canadian refuse dumps.” (Hamilton, et al. 1988:33)

Based on this information, it was concluded that the area immediately adjacent to the fort was the best place to find associated Aboriginal occupations. The best camp locations on the opposite bank were likely near the water’s edge with easy access from the upper terrace, and perhaps near the mouth of a creek with fresh water. Any such areas not already identified for high potential grid testing were tested using judgemental shovel tests.

All other potential test locations in the vicinity of the fort were either outside the LAA or on lands modeled as high potential and subject to grid testing. Some locations on the opposite bank were also examined in 1981, when SFU tested approximately 2 km of the north bank with 30 cm shovel tests, 50 paces apart.

5.1.5.11 Cross Discipline Integration

Recognizing potential synergies between the archaeological, historical, and palaeontological field programs, crews from all three disciplines were in regular communication with operational personnel with respect to discoveries of fossil material, artifacts, and historical remains so that previously undiscovered locations could be investigated by crews from the appropriate discipline.

5.1.5.12 Field Data Collection and Management

The CartoPac application is intended to largely replace the field notebook and field map. It is designed with forms that allow for the recording of archaeological potential assessment, subsurface tests (including grid, adaptive, and evaluative unit), surface and subsurface features, surface artifacts, artifact collections, sample collections and general observations (see Appendix B for specific form content).

For the archaeological program, the CartoPac software application was used for data collection and management. The application is a Windows 6 mobile application run on a Trimble Nomad GPS-enabled data logger paired with a Trimble Pro-XT receiver capable of sub-metre accuracy. The CartoPac application addressed the following quality assurance and logistical considerations of the Project:

- Multiple crews collecting large volume of data simultaneously
- Need for geo-referenced data
- Data housed in a relational database that can queried
- Ability to do spatial queries
- Short timeline for quality control checks and reporting
- Multi-year project
- Staged research design
- Several types of base reference imagery used in the field (e.g., TRIM, air photos, predictive model)

The CartoPac application uses custom user-designed “smart” forms as the user interface on the mobile device. The forms are “smart” in that data collection content can be quality assured through the use of drop-down menus, required fields, alphanumeric content control, and spatial tools (i.e., data point, polygon, or line). Modifications to the forms can be made remotely by the data manager and pushed through to the fieldworker via email. CartoPac also allows the unit to carry gigabytes of base images to help the user navigate to an area that needs to be assessed, and then record observations and test results in forms that are geo-referenced to the location.

5.1.5.13 Site Evaluation and Recording

All protected archaeological sites identified during the AIA were photographed and recorded to BC Archaeology Branch standards (e.g., British Columbia Archaeological Site Inventory Form Guide [2009b]) and have been, or will be, entered into the Provincial Heritage Register.

5.1.5.14 Site Boundaries

Where archaeological sites were identified, adaptive subsurface testing was used to help define site boundaries. Sites were not flagged, to avoid attracting unnecessary attention.

Archaeological site boundaries were defined on the basis of observed (following subsurface testing methods as above), natural, or arbitrary limits, or any combination thereof, as follows:

- Observed boundaries were determined by the extent of archaeological materials or features, as observed on the surface, in exposures, through subsurface testing, or a combination thereof. Site boundaries were set 2.5 m beyond the last positive test or surface find.
- Natural boundaries were defined by the extent of a related landform (e.g., hillock) or a limiting natural feature (e.g., stream). Some site boundaries were set at a break-in-slope (e.g., terrace edge), typically one or 2 m below the break. In a few cases, the site boundaries were established around the toe of small, well-defined landforms.
- Arbitrary boundaries reflect either artificial or administrative boundaries, such as property lines, a right-of-way boundary, or the presence of existing impacts or developments. Arbitrary boundaries were also established where sites extended beyond the LAA.
- Previously recorded boundaries were used where the site could not be relocated, or where the site could not be revisited due to access constraints. Existing boundaries were also retained on sites where the reported boundary extended beyond the site area defined by testing or surface inspection during the Project.

The type of boundary (i.e., observed, natural, arbitrary, or previously recorded) used to define each site was indicated in the site summaries in this report. For previously recorded sites, information from existing site records, reports and, where possible, field notes from the 1970s Site C archaeological studies were used to confirm site locations and characteristics.

5.1.5.15 Artifact Collection and Recording

Artifacts and other archaeological remains encountered in subsurface tests or observed on the surface of a site were recorded as to location (e.g., test number, parcel, and coordinates), type (e.g., lithic, faunal, organic) and material (Appendix N-2, Photograph 14). Archaeological materials recovered from subsurface tests were collected for further laboratory analysis. Analytical procedures for lithic artifacts and faunal remains are outlined below. Observed surface materials were also collected, except in 2011 where a program of systematic surface inspection of ploughed field took place prior to the issuance of an amended British Columbia *Heritage Conservation Act* permit. Materials collected for analysis and dating purposes included temporally diagnostic artifacts, artifacts made of obsidian, and charcoal, bone, and sediment samples.

5.1.6 Analytical Methods

5.1.6.1 Lithic Analysis

Analyses of lithic artifacts recognize two distinct classes of artifacts: formed tools and debitage (Magne 1985; Kooyman 2000; Odell 2004; Andrefsky 2005). Formed tools are artifacts that exhibit intentional human modification, such as retouch or grinding. For example, a uniface will display retouch to one or more lateral margins of the dorsal or ventral side only. In contrast, a biface has been retouched on both the dorsal and ventral faces that meet to form a single edge. Debitage is unmodified flake or shatter material detached from the original core that has been discarded during the reduction process. These flakes are the waste products of lithic reduction and tool manufacture and are the most abundant artifact class at most archaeological sites in the LAA. Laboratory methods and artifact attributes for both classes are described in detail below.

Tool types identified in the artifact assemblage, based on their overall morphology, are summarized in Table 5.1. The typology is based on research by Magne (1985) and modified as necessary when artifact types such as abraders, micro- and macroblades were recovered that were not present in Magne's original study.

The attributes recorded for formed tools were length, width, and thickness. All measurements were made with digital calipers and recorded to the nearest tenth of a millimetre. Edge angle was also measured where appropriate in 5º increments using a contact goniometer. Lithic raw material was recorded for each artifact. The method for recording lithic material type is discussed in Section 5.1.6.1.2.

Debitage was classified according to the presence or absence of a striking platform. A striking platform is defined as the surface area on an objective piece receiving the force necessary to detach a flake or blade (Crabtree 1982; Andrefsky 2005). Debitage with platforms present were termed platform remnant-bearing flakes while those flakes without platforms were simply classified as shatter (Magne 1985). Two other debitage classes were identified, bifacial reduction flakes and bipolar flakes. These flakes types are representative of specific reduction processes and therefore were treated as distinct artifact types.

Debitage attributes recorded for this study were derived from the experimental classification scheme developed by Magne (1985) that distinguishes reduction stages based on a limited number of attributes. The attributes recorded for debitage were:

- Dorsal scar count (DOCO) for flake scars 5 mm or larger
- Platform scar count (PLCO) for all scars regardless of size not including platform preparation scars
- Platform angle (PLAN) measured on the dorsal surface in 5º increments using a contact goniometer
- Cortex cover (COCO) estimated in five increments of 25% including 0% and 100%

Size class was also recorded for each flake following the scheme shown in Table 5.2. All of the above attributes were recorded for platform remnant-bearing flakes, bifacial reduction, and bipolar flakes. Only size, dorsal scar count, and cortex cover were recorded for shatter.

Table 5.1: Tool morphology types

Tool Type	Description
Large bifaces (LABC) and fragments (LABF)	Bifacial tools or fragments thereof exceeding 10 cm in any dimension
Bifacial retouch tool (BIFC) and fragments (BIFF)	Artifacts with flaking or retouch on two adjoining faces that meet to create a single edge
Unifaces (UNFC) and fragments (UNFF)	Tools with flaking or retouch on either the dorsal or ventral faces only
Utilized flakes (UTIL)	Flakes with no intentional retouch, but exhibiting contiguous, non-random use-related edge damage to one or more margins
Projectile points (PROC) and fragments (PROF)	A bifacial tool distinguished by the presence of a hafting element in the form of side- or corner-notches or thinning of the basal margin and used as a projectile tip
Gravers/drills (GRDR)	Tools with deliberately retouched projections and not meant to be projectile points
Endscrapers (ENDS)	Steeply retouched unifacial tools with rounded distal margins
Pièces esquillées (PEEQ)	Wedge-shaped, battered artifacts associated with bipolar percussion
Spall tools (SPTO)	Large flake tools often with retouch in various ways to accommodate hafting and scraping elements
Core tools (COTO)	An objective piece that exhibits one or more flake removal scars functioning primarily as the source of flake blanks, but possibly also used as a chopping or cutting tool
Hammerstones (HAMM)	Unmodified cobbles used to detach flakes from a core. Battering damage may be present on one or both ends
Microblades (MCBC) and fragments (MCBF)	Small, parallel sided flakes bearing no further modification created through a specific reduction process. Usually these artifacts are not longer than 25 mm
Macroblades (LBDC) and fragments (LBDF)	Parallel sided flakes similar to microblades, but larger. Dorsal surface exhibits two or more scars of previous blade removals
Abraders (ABRD)	A coarse-grained rock used to smooth or grind other materials, such as wood, rock, or shell

SOURCE:
Modified from Magne (1985)

Table 5.2: Debitage size classes

Size Class	1	2	3	4	5	6	7
Size Range (millimetre)	0.0 to 1.0	1.1 to 2.0	2.1 to 3.0	3.1 to 4.0	4.1 to 5.0	5.1 to 6.0	6.1 to 7.0

5.1.6.1.1 Artifact Cross-dating

Diagnostic artifact types, such as projectile points (e.g., “arrowheads” or spear points) are conventionally believed to have been changed stylistically over time. These finite temporal distributions provide a means for using diagnostic artifact styles as “index fossils” to provide relative dates for sites where no organic materials are present to provide a radiometric date. The age range for many projectile point styles has already been established by culture historical methods, such as provenience comparative studies, and, in best case scenarios, are supported by radiometric dating of associated cultural materials. For much of British Columbia and neighboring regions, projectile point sequences are fairly well known (Spurling 1980b; Richards and Rousseau 1987; Kooyman 2000; Carlson and Magne 2008) and the presence of a projectile point at an archaeological site can provide an approximate date range for the occupation of that site. Other artifact types such as micro- and macroblades are also recognized as being temporally sensitive (Spurling 1980b; Fladmark 1985a).

All diagnostic artifacts were compared to similar artifacts from the Peace River valley and surrounding regions. Past research has documented cultural affiliations between the upper Peace River region and other regions such as the Yukon and Northwest Territories, the northern Plains, and central interior and northwestern British Columbia (Spurling 1980b).

5.1.6.1.2 Lithic Raw Material Types

The determination of lithic raw material types was based on visual, macroscopic inspection of individual artifacts, and considered such attributes as colour and grain-size or texture. When a rare or uncommon material was present in the artifact assemblage, documentary research was undertaken to search for other occurrences of the material in the region. Previous studies in the Peace River region (e.g., Spurling 1980b) have identified several of the most common material types present in archaeological contexts and provide valuable reference information for the current study. The predominant lithic material present in lithic assemblages was chert, a cryptocrystalline silicate that occurs in a variety of colours, with solid black and black and grey banded variants being the two most common. The grain-size or texture of regional chert types ranged widely from very fine to coarse. Several other material types were also present in the study area and include other crypto- and microcrystalline silicates, such as chalcedony, quartzite and other quartz-based rocks, as well as a variety of silicified siltstones. Grain size and inclusions were used to help distinguish between materials such as silicified siltstone and black chert that have similar general appearance.

Obsidian artifacts were also identified in archaeological sites in the LAA. This material does not occur locally and therefore was transported from distant sources. It is possible to determine the source locations for obsidian using x-ray fluorescence spectrometry, a non-destructive analytical method that can accurately measure trace element concentrations in obsidian. By comparing the concentrations in the sample artifact to those from known source locations, it is possible to identify the source of the artifact.

5.1.6.2 Faunal Analysis

Following Driver (1992), identifications were made using a comparative osteological collection, supplemented by published guides (e.g., Gilbert 1990; Balkwill and Cumbaa 1992; Brown and Gustafson 2000). This zooarchaeological reference collection is housed at SFU's Department of Archaeology. Identifiable bones were checked against potential species, based on previous studies in the Fort St. John area in both Pre-contact (e.g., Spurling 1980b; Heritage North 1990, 1991; Driver 1988; Archer 2009a, 2009b) and Contact era assemblages (e.g., Fladmark 1975; Hamilton, et al. 1988). Although most soil types in the LAA are not acidic, little identifiable bone has been found here (cf. Archer 2009a), and most of the faunal remains recovered by archaeologists in the region are unidentifiable, calcined fragments found in hearth contexts (e.g., Heritage North 1990, 1991). Where bones were complete enough to allow for identifications, these were done to the most confident taxonomic category; in cases where features were lacking to confidently determine Artiodactyla species, for example, bones were identified as artiodactyl.

Observed modifications to bones were recorded, including burning, cut marks, and spiral fractures or impact scars. Identified fauna were quantified using number of identified specimens present (NISP), the long-standard measure in zooarchaeological analyses (Grayson 1984; Brewer 1992).

5.1.6.3 Radiocarbon Dating

Radiocarbon dating was used to estimate the age of sites, where appropriate samples were recovered. All living things maintain a content of radiocarbon (also referred to as carbon-14, C14, or ^{14}C) in equilibrium with that available in the atmosphere. When an organism dies it stops taking in new carbon. The ratio of carbon-12 to carbon-14 at the moment of death is the same as every other living thing, but the carbon-14 decays and is not replaced. At this stage the amount of carbon-14 available within the organism begins to decay into nitrogen-14 (^{14}N) at a half-life rate of 5,730 years (in that, it takes 5,730 years for half of the carbon-14 available in the organism to decay) while the amount of carbon-12 remains constant. Laboratories are able to look at the ratio of carbon-12 to carbon-14 in the sample and by comparing it to the ratio in a living organism, are able to determine the age of a formerly living thing fairly precisely and assign it a radiocarbon date. These dates are referred to in "radiocarbon years" or "the conventional radiocarbon age" or "radiocarbon years before present" (where "present" is defined as AD 1950). Because the amount of carbon-14 in the atmosphere fluctuates over time, radiocarbon dates require calibration against established curves.

All radiocarbon dating employed the accelerated mass spectrometry (AMS) technique, which allows for dating of smaller samples than standard radiocarbon dating. Analyses were conducted by Beta Analytic Inc. of Miami, Florida. Radiocarbon samples were measured, verified, and calibrated to the radiocarbon and solar calendars using the IntCal04 database.

Charcoal and bone samples were submitted to Beta Analytic for AMS radiocarbon dating. Bone samples were submitted in labelled plastic bags, and charcoal was wrapped in tinfoil and plastic bags, following instructions provided by Beta Analytic. Samples were treated by Beta Analytic using alkali, or acid and alkali.

Samples were chosen based on their provenance, as well as judgemental expectations of their suitability for radiocarbon dating. Many of the samples were considered unlikely to yield dates based on Beta Analytic's recommendations for sample size and condition. Most of the recovered bone was in the form of small, calcined fragments falling short of the 4 to 40 g recommended weight for dating burned bone. Larger bone fragments and samples of unburned bone were also selected for AMS dating.

5.1.6.4 Assessment of Erosion Potential

To assess the potential effects of erosion on heritage sites, a technique was developed to quantify the degree to which specific archaeological and historical sites within the LAA may potentially be impacted by natural and human erosion. The technique has been designated the Erosion Potential Assessment Scoring Technique (E-PAST).

Erosion of archaeological sites is related to the inundation of the site by water stored in the reservoir. Although inundation by itself is not sufficient to result in erosion, moving water resulting from waves and currents has the potential to erode sites that were not exposed to these conditions prior to inundation. Once a site is subject to moving water, the velocity of the water and the ability of surface materials to resist erosion determine to some extent whether a site can be expected to experience erosion. Additionally, archaeological sites around the perimeter of the reservoir may also be affected by reservoir erosion even if they lie outside the actual reservoir footprint. An example of this would be a site at the top of a steep slope, the toe of which is subject to shoreline erosion when the reservoir is inundated.

The E-PAST tool was applied to archaeological and historical sites located within and adjacent to the reservoir, to a maximum elevation of 466 masl, which corresponds to the peak reservoir level during the probable maximum flood.

E-PAST analysis variables are described in the sections that follow.

5.1.6.4.1 Driving Forces – Factors That May Increase Erosion

Natural erosion is controlled by driving forces or elements such as ice, waves, and wind, all of which may influence the rate of erosion. The location of a heritage site, along the Peace River shoreline for example, determines the degree to which the site could be impacted by wind, waves, and ice. The variables considered in the analysis are the fetch length, depth at full pool (water depth at site), and shore orientation and exposure, which may be taken as proxies for the likely effect of ice, waves, and wind. The following sections describe the driving force variables that were measured to assess erosion potential.

Fetch Length

Fetch length is a term for the length of water over which a given wind has blown. In general, for a given depth of water, fetch length and wind speed determines the size of waves produced. Fetch is measured as the longest open-water distance from a site to the opposite shore. In a long flooded valley, the longest fetch may be oriented more along the valley than across the valley and will depend on the orientation of the local topography. In general, sites with longer fetches are exposed to larger waves and stronger ice-push, and thus are more susceptible to erosion than more protected sites with shorter fetches or less exposure. In E-PAST, typically a site with a long fetch would receive a higher score than a site with a shorter fetch. This variable will calculate the Fetch Score based on a scale ranging from <0.5 to >48 km. The scale is derived from typical lengths and widths of freshwater lakes.

Depth Modifier

A second variable measured by this technique is depth at the probable maximum flood level, referred to as a Depth Modifier based on a scale ranging from <10 m to >30 m. The scale is derived from the typical depths to which waves interact with the bed. This is based on the elevation difference between the site and the probable maximum flood level. The Depth Modifier considers the physical protection of sites by deep water, such that sites covered by deeper water are less exposed to erosion than sites covered by shallower water. The Depth Modifier reduces the effectiveness of the fetch if the water is deeper. In E-PAST, addition of the Depth Modifier to the Fetch Score results in the Modified Fetch Score. The Modified Fetch Score is used to calculate the score for the forces causing erosion.

Terrain Exposure

The orientation and exposure of a particular area of terrain are also factors in determining erosion potential scores. The Exposure Score is based on the exposure of the shoreline to prevailing winds. The direction of exposure should coincide with the direction in which the fetch is determined. Wind data at Fort St. John Airport over the period of 1971 to 2000 have been used for the assessment of exposure. Sites exposed to stronger winds will receive higher scores than sites which are sheltered from the wind. In the case of the Project, sites oriented to the northeast are exposed to weaker winds then those oriented to the northwest and southeast. Sites oriented to the southwest are exposed to the strongest winds. In E-PAST, the Exposure Score (based on scale of 0° to 360°) is used to calculate the score for the forces causing erosion.

Driving Forces Score

The Driving Forces score represents the strength of the erosional forces potentially affecting a site. The higher the score, the more erosional energy may reach that site. The score is determined as follows:

Driving Forces = Modified Fetch Score x Exposure Score

5.1.6.4.2 Resisting Forces – Factors That May Reduce Erosion

Natural erosion is tempered by resisting forces or elements such as the type of surface materials or the overall slope gradient, all of which may influence the rate of erosion. The surface materials and terrain of a heritage site along the Peace River shoreline for example, determines the degree to which the site could resist erosion. The variables considered in the analysis are the terrain composition and the slope gradient.

Terrain Composition

Ground surface composition influences the ability of a landform to resist erosion. For example, sites with bedrock and coarser-grained materials (e.g., cobbles) are more erosion resistant than sites with silts and loose sand at the surface. In E-PAST, the calculated Terrain Score is based on the surficial geology of the site (scale of 1 to 5 based on surface material type) with coarser-grained surface materials receiving a lower score than finer grained materials due to their ability to resist erosion.

Slope Gradient

The slope gradient of the ground surface also affects the amount of erosion that may occur. In general, steeper slopes are more prone to erosion by wind, waves, and runoff than shallower slopes, although the surface geology also is a factor. E-PAST cross-references the slope gradient of a site with the surface materials to determine a Terrain Modifier (scale from <5° to >25°). The Terrain Modifier is used to include slope gradient in the calculations of resisting forces.

Resisting Forces Score

The Resisting Forces score is determined by adding the two scores:

Resisting Forces = Terrain Score + Terrain Modifier

5.1.6.4.3 Natural and Human Potential

The Erosion Potential at a site is based on both the natural erosion potential and the potential for erosion by human activity. These are calculated in E-PAST from available data.

Natural Potential

The Natural Potential for erosion is determined by multiplying the Driving Forces score and the Resisting Forces score.

Human Potential

The human potential for erosion is based on how easy the site is to access and what kind of access is available. For example, sites with evidence of known or apparent access (i.e., vehicle access to site) receive a higher score than a heritage site with low access. A Human Potential Score is determined by evaluating the ability of people to access a site (based on a scale from 0 to 10) considering both existing access and post-development access. Boat wakes are not specifically included here as they will be less dominant than wind waves, which have been included in the Driving Forces analysis.

EROSION POTENTIAL

The overall Erosion Potential Score is arrived at by adding the Natural Potential Score with the Human Potential Score:

Erosion Potential Score = Natural Potential + Human Potential

The results of the erosion assessment and site-specific scoring sheets are provided in Appendices M-1 and M-2.

5.1.7 Archaeological Site Significance Evaluation Methods

Archaeological significance was evaluated by applying the Checklist of Criteria for Pre-contact Site Evaluation found in Appendix D of the *British Columbia Archaeological Impact Assessment Guidelines* (BC Archaeology Branch 1998). This checklist is used to evaluate the scientific, public, ethnic, and economic significance of archaeological sites.

The scientific significance of known archaeological sites within the LAA was assessed on the basis of artifact frequency, artifact density, the presence of expedient and formed tools, the presence of temporally diagnostic tools, the presence of obsidian, intrasite variability, the presence of cultural features, the presence of materials suitable for radiocarbon dating, the presence of burials, and the integrity of the site setting.

Artifact frequency is the number of tools and faunal remains recovered from a site, whereas artifact density refers to the number of tools and faunal remains found per test on each site. Moderate or high artifact frequency and density positively influenced the significance assessment. Low artifact frequency or density negatively influenced the significance assessment.

Most of the lithic assemblage recovered in the LAA consisted of debitage (see Section 5.2.5.1.1). The expedient tools and formed tools categories therefore register the presence of lithic tools. The presence of temporally diagnostic tools permits archaeological cross-dating of a site or site component (see Section 5.1.6.1.1). The presence of obsidian (see Section 5.1.6.1.2) also positively influenced the significance rating, as this non-local lithic material can be matched to its geological source\ and may be indicative of past exchange networks. An absence of obsidian was considered to have no effect on ascribed significance.

The category of intrasite variability documented the presence or absence of the clusters of artifacts or features. Such clusters are often the archaeological correlates or activity areas (e.g., lithic tool production or subsistence features), or indicate multiple occupations of a site over time. Sites with demonstrated or suspected intrasite variability have the potential to better inform our understanding of the past, and therefore the presence of this trait positively influenced a significance rating. The lack of intrasite variability typically had a neutral influence on site significance.

Faunal remains provide additional evidence of past subsistence activities. Faunal remains are rarely preserved in the Peace region, so where they were found in the LAA, their presence was considered to increase site significance. The presence of material suitable for radiocarbon dating (see Section 5.1.6.3) likewise positively influenced a site's significance rating.

Traits such as palaeosols, stable dunes, and rock shelters, may permit geoarchaeological studies to be conducted. Such sites are relatively uncommon within the LAA, and therefore the presence of such traits positively influenced site significance. Likewise, confirmed human burials are rare in the LAA, and the presence of a reported burial had a positive influence on site significance. The lack of these traits typically had a neutral influence on site significance.

Archaeological integrity refers to the degree of disturbance that has occurred at an archaeological site. An intact site is one in which there has been minimal or no natural disturbance (e.g., slumping or aeolian deflation) or anthropogenic disturbance (e.g., logging, cultivation, road construction). A site with little disturbance received a higher significance rating than one which had be moderately disturbed (e.g., clearing of a transmission line right-of-way) or heavily disturbed (e.g., the construction of a gravel pit).

Scientific significance could not be evaluated for 12 sites that were found to be too heavily disturbed to warrant subsurface testing or were not relocated, and for which existing site records were inadequate to ascribe a meaningful assessment. In these cases, scientific significance was classified as “undetermined”.

Table 7.2 summarizes the scientific significance evaluations of archaeological sites within the LAA, and site-specific evaluations are provided in Appendix I.

5.2 Archaeological Results

The results of archaeological investigations within the heritage resources LAA are provided in the sections that follow. This includes the results of:

- Documentary research
- Archaeological overview assessments of the dam site adjacent construction areas and off-site construction materials areas
- Field investigations, including 2010 predictive model testing
- Artifact analysis
- Faunal analysis
- Radiocarbon analysis
- Site distribution analysis

5.2.1 Archaeological Documentary Research Results

A review of published and unpublished archaeological literature and other heritage resource information was conducted by the Golder team for the Site C Project. For the purposes of this review, a regional study area (the “Peace region”), is defined as those lands in northeastern British Columbia within the amended coverage area of British Columbia *Heritage Conservation Act* Permit 2010-0378 and adjoining parts of northwestern Alberta drained by the Peace River. The Peace region as defined here measures 4,345,256 ha in area, and is not to be confused with the heritage resources LAA (see Volume 4 Section 32 Heritage Resources).

Reports describing archaeological investigations (that is, excavations) in the Peace region were identified and reviewed as part of the literature review. The results of previous archaeological studies for the heritage resources LAA were important sources for this study, predominantly including work done by Simon Fraser University between 1974 and 1980 (e.g., Fladmark 1975, 1979, 1981; Spurling, et al. 1976; Fedje 1977; Spurling 1978, 1980a, 1980b; Alexander 1982; Wilson 1979), as well as studies done more recently (e.g., Archer 2008a, 2008b; Arcas 2009; Golder 2009a, 2009b, 2009c, 2009d, 2010a, 2011b; I.R. Wilson 2009).

5.2.1.1 Archaeological Studies for the Site C Project

Previous archaeological research within and adjacent to the LAA principally involved a multi-year inventory study conducted by archaeologists from SFU, directed successively by Knut Fladmark, Brian Spurling, and Diana Alexander.

Simon Fraser University conducted a number of archaeological surveys, spanning eight years, for the Project as part of preliminary design works prior to a 1981 British Columbia Utilities Commission review of the Project (Spurling 1980a, 1980b; Alexander 1982). The principal SFU investigations within and adjacent to the LAA during that period include:

- Field studies for the proposed Site 1, Site C, Site E, and Dunvegan Dam projects in 1974 (Fladmark 1975)
- Field studies for the proposed Site C reservoir in 1976, focused on the south side of the Peace River (Spurling, et al. 1976)
- Two seasons of site inventory and impact assessment field work in 1977 and 1978, using probabilistic sampling (Spurling 1978, 1980a, 1980b)
- An inventory and impact assessment of the Site C to Peace Canyon transmission line corridor in 1977 (Fedje 1977)
- An archaeological field school in the Peace River valley that involved site excavation and historical research (Fladmark 1979); this project investigated a number of sites potentially affected by the Project, but was not part of the studies conducted for the Project
- A site inventory and impact assessment of the dam site in 1981, using a mixed probabilistic and judgemental survey approach (Alexander 1982)

In addition to the SFU work, Wilson (1979) undertook an inventory and impact assessment of seven sections of the transmission line not inspected as part of Fedje 1977.

The research undertaken by SFU identified and recorded over 300 archaeological and historical heritage sites within and near the LAA. Of these, detailed excavations were undertaken at two Pre-contact sites, small-scale excavations were undertaken at nine sites, and systematic surface collections were conducted at eight sites (Spurling 1980a; Alexander 1982) as detailed below:

- Detailed excavations at sites HaRk-1 and HaRk-14
- Small-scale excavations at GlRj-1, HaRj-14, HaRj-19, HbRf-62, HbRg-5, HbRh-8, HbRh-33, HbRh-44, and HbRh-66
- Systematic surface collection at HaRk-40, HaRk-41, HaRk-42, HbRh-17, HbRg-15, HbRi-9, HbRi-33, and HbRi-34 (Arcas 2009)

Work also took place at the fur-trade era Rocky Mountain Fort and Rocky Mountain Portage House. Archaeological excavations in the 1970s and 1980s at Rocky Mountain Fort near the mouth of the Moberly River included site mapping and test excavations, preparation of a detailed contour map and proton magnetometer survey, and intensive excavations of 130 m² of site matrix (Spurling, et al. 1976; Burley and Hamilton 1991; Burley, et al. 1996; Arcas 2009). To date, approximately 22% of the site has been excavated, with a majority of the excavations focusing specifically on structural remains (Burley 1990:8).

In 1974, the site of Rocky Mountain Portage House was relocated opposite Hudson's Hope by Knut Fladmark, "as a complex of low mounds and shallow depressions enclosing a rough quadrangular area" (Fladmark 1975:53). In 1974, the site had been affected by "modern construction" including log cabins, as well as a road and ferry landing area (Fladmark 1975:53). In 1977, the site was mapped and surveyed in greater detail (Burley 1990:12). In 1987, a small number of shovel tests (i.e., half-metre square test units) were placed between the identified depressions and mounds. Few artifacts were recovered from the site, and Burley, et al. (1996:72) contend that the "Rocky Mountain Portage House we had been excavating was clearly that of the third incarnation [i.e., 1860s through 1882 to 1899]."

After the early 1980s and prior to the onset of current investigative work for the Project, a number of office- and field-based studies were carried out, either for the Project or to address other regulatory requirements for BC Hydro. These studies included:

- A desktop review of documented and potential heritage resources within the footprint of the Project to provide background information for BC Hydro and to identify changes in provincial cultural resource management standards implemented since the SFU studies were concluded in 1982 (Arcas 1991)
- An office-based assessment of the vulnerabilities of archaeological resources to fluctuating water-flows on the Peace River downstream from the Peace Canyon Dam (Arcas 1994)
- An in-office review to summarize traditional Aboriginal land use and ecological knowledge for the Peace Water Use Plan Committee (Arcas 2002)
- Archaeological investigations at an archaeological site inadvertently disturbed by geotechnical investigations for the Project (Archer 2008a)
- An archaeological overview assessment of impervious aggregate material supply locations and potential slide zones within a 10 km radius of the dam site (Archer 2008b)
- A desktop study to reconcile conflicts between written records of heritage site locations within the Project footprint and their geo-spatial coordinates in the Provincial Heritage Register (I.R. Wilson 2009)
- A heritage resource data gap analysis for the Project (Arcas 2009)
- Archaeological impact assessments for geotechnical investigations and similar activities within the dam site and other Project components, beginning in 2009 and continuing concurrently with Site C heritage program (Golder 2009a, 2009b, 2009c, 2009d, 2010a)
- An archaeological overview assessment of geotechnical investigations within the dam site (Golder 2010b)
- A study of erosional effects on archaeological resources by BC Hydro reservoir operations in the Peace basin. The study selected two sites on the Peace River as test locations, including one site (HbRh-8) within the reservoir and a historical site (HbRe-1) downstream from the dam site at Old Fort St. John (Millennia 2011)

- A predictive model of archaeological resource potential for the LAA (Millennia 2010a, 2010b), which was subsequently tested during the 2010 field program (Golder and AMEC 2011)
- An archaeological overview assessment of lands adjacent to the reservoir (Golder and AMEC 2011)
- Archaeological overview assessments for quarries and excavated construction material areas (Wuthrich Quarry, West Pine Quarry, Portage Mountain, Del Rio Pit, and Area E) and the as yet undefined construction activity areas near the dam site. Within these areas there are 10 previously recorded archaeological sites that are considered part of the existing baseline, but they are not included in mitigation planning or the effects assessment because they have not yet been assessed in the field (see Section 5.2.3).

5.2.1.2 Archaeological Resources of the Peace Region

Within the Peace region as shown in Figure 5.3, there are 2,551 documented heritage sites recorded in British Columbia and 705 sites recorded in the adjacent portion of Alberta. These numbers include both prehistoric archaeological sites and historical heritage sites, as well as a small number of palaeontological fossil occurrences in British Columbia that were recorded in the Provincial Heritage Register before 1994. The distribution of these sites reflects the relative level of effort made by archaeologists to find sites within the landscape encompassed by the Peace region.

Within the LAA there are 251 recorded Pre-contact heritage sites, of which 219 were revisited or identified and recorded by the 2010 to 2012 field programs. Twenty-two additional, previously recorded sites have not yet been revisited, as they are situated upon private lands where access was denied to the Golder team. Another 10 sites are located within project components, but have not yet been assessed by the field program since the development plans are not adequately advanced to allow for a thorough assessment.

Figure 5.3 shows higher site densities in British Columbia when compared to the neighbouring region of Alberta, likely reflecting differing standards of practice between the two jurisdictions. Most of the archaeological sites shown in British Columbia were discovered during assessments of oil and gas developments, according to more rigorous provincial standards. Thus, while the dense concentration of sites discovered by SFU and the Golder team for the Site C Project stands out along the Peace River, there is a more even distribution of archaeological sites throughout the remainder of the landscape. It is reasonable to assume that site densities comparable to British Columbia are also present in the Peace River valley and in landward settings in the Peace region of Alberta, but remain to be discovered and recorded.

5.2.1.3 Archaeological Resource Inventory – Level of Effort and Data Gaps

Archaeological site data downloaded from the Provincial Heritage Register identifies locations where archaeologists have recorded sites during field studies. However, an archaeological field survey typically covers a much larger area than that encompassed by a single archaeological site, and information about lands where no sites have been found is just as important to the research carried out for the Site C Project.

The BC Archaeology Branch requires that reports submitted to fulfill the conditions of Heritage Inspection and Site Alteration Permits include shapefiles showing the extent of survey coverage achieved by the study (BC Archaeology Branch 2011). This requirement is recent, and reports older than four or five years do not usually portray such information in an accessible format. In British Columbia, records of archaeological study locations that are known to have included field surveys or other assessments are also maintained by the British Columbia Oil & Gas Commission and the British Columbia Ministry of Forests, Lands and Natural Resource Operations, and can be obtained as shapefile data through the GeoBC online application. Reviewing these data provides a measure of confidence that the documented presence of archaeological sites does or does not reflect the actual distribution of those resources within the landscape. However, comparable data were not obtained for adjoining portions of Alberta, and only site distribution information from that province is used in this analysis.

The data show that 564,166 ha of the Peace region (total area = 4,345,256 ha) have been covered by previous archaeological studies, representing 13% of the landscape within the British Columbia component of the Peace region as defined in Section 5.2.1.2. This is a high value compared to most other regions in British Columbia, which tend to average between 7% and 8% coverage by archaeological studies (AMEC 2010). These studies have principally included the following:

- Overview assessments with field reconnaissance components
- Archaeological impact assessments
- Academic research excavations
- Systematic data recovery for impact mitigation projects

Most of these lands were inspected during assessments for proposed resource developments, as well as more localized settings covered for small-scale land developments or academic research projects. Also included are non-inspected oil and gas developments for which Archaeological Assessment Information Forms have been prepared (B.C. Oil and Gas Commission 2012). Because the BC Archaeology Branch did not require survey-area shapefile data prior to 2009, this summary does not fully portray the extent of archaeological studies by academic researchers and development-driven impact assessments, other than forestry or oil and gas developments, that took place before that year.

According to the same data sources described above, 2,601 ha of the heritage resources LAA (total area = 15,453 ha) have been covered by previous archaeological studies, representing approximately 17% of the landscape within the LAA. The numbers include 2,066 ha covered during assessments of proposed forestry developments (13% of total land base; 79% of lands covered by archaeological studies). A total of 258 ha have been covered by assessments for oil and gas developments (2% of total land base; 10% of lands covered by archaeological studies). Other kinds of archaeological assessments, including the SFU assessments for the Site C Project, have covered 277 ha (2% of total land base; 11% of archaeological coverage).

When intensive, systematic assessments of proposed resource developments commenced in the Peace region between approximately 1990 and 1995, little was known about the distribution and density of archaeological resources. The data summarized above indicate that is far from the case today. There are few regions in British Columbia, or for that matter in the adjoining part of Alberta, where archaeological site distributions are as well-defined as they are in the Peace region. The present-day inventory of archaeological sites is the result of extensive archaeological inventory, and is not correlated with the distribution of cleared agricultural lands.

The majority of recorded sites in the Peace region are composed of small, low-density artifact scatters, as was predicted by earlier researchers (e.g., Donahue 1976; Ives 2003). Recent archaeological research in the Williston Reservoir draw-down zone, in a landscape denuded of its native soil and vegetation—the traditional impediments to finding archaeological sites in forested environments—shows that artifacts and other cultural materials are numerous and are scattered sporadically throughout the entire exposed landscape (e.g., Arcas 2003, 2007; Millennia 2008, 2010). This distribution may prove to be analogous to the distribution of archaeological resources in the Peace region generally, including those parts of the LAA that are outside the Peace River valley. Within the Peace River valley, the different depositional environment has allowed for the formation of stratified archaeological sites that may be infrequently found elsewhere in the region.

5.2.1.4 Archaeological Investigations within the Peace Region

Figure 5.4 identifies the locations of prehistoric and historical heritage sites where some sort of detailed investigation (most often, an excavation) has taken place. The area covered includes that part of British Columbia and Alberta within the Peace region as defined previously.

The scope of such investigations ranges from multi-year academic research projects (e.g., Fladmark, et al. 1988; Driver, et al. 1996; Heritage North 2004) to systematic excavations of single sites (e.g., MacNeish 1960; Fladmark 1979; Spurling 1980b; Wright 1991; Berezuik 2001; Archer 2009a), detailed site testing or small-scale mitigation projects (e.g., Alexander 1982; Bryan and Conaty 1976; Arcas 2007), and systematic surface collections (Spurling 1980b). The studies that were examined reflect published and unpublished manuscript documents available as of 2011; additional reports may have been completed since then that are not cited in this report. Furthermore, it is acknowledged that reports of additional investigations in the Peace region may exist, but were not captured by the document search parameters used for this research. Therefore, the number of reports cited below should be regarded as a minimum figure for each province.

Based on the document search, there have been at least 66 archaeological sites excavated or otherwise investigated in the “GR” and “HR” Borden blocks of northeastern British Columbia, and 30 sites investigated in the “FQ”, “GQ,” and “HQ” Borden blocks in Alberta, mostly of prehistoric attribution. However, six historical sites have been investigated in Alberta (Kendal 1972; Pyszczyk 1983, 1984; Pyszczyk, et al. 1987; Kowal 1991, 1992; Smith, et al. 1991; Porter 2008; Golder 2009) and three excavated in British Columbia (Spurling, et al. 1976; Fladmark, et al. 1977; Williams 1978; Burley and Quackenbush 1986; Hamilton 1987; Hamilton, et al. 1988; Yellowhorn 2002; Norcan Heritage 2009).

The documentary research suggests that while there may be regions of British Columbia and Alberta where a higher frequency and diversity of archaeological sites have been investigated, at least 96 sites in the Peace region have been investigated. These investigations have involved a variety of methodological approaches (e.g., systematic excavation, evaluative testing, surface collection) and included sites in a variety of environmental settings. Although academic researchers have tended to focus their investigations on Paleo-Indian sites (e.g., Fladmark, et al. 1988; Wright 1991; Driver, et al. 1996), archaeologists have obtained radiocarbon dates and found temporally diagnostic artifacts that represent most if not all of the approximately

11,000 years of human history in this region (e.g., Spurling 1980b; Alexander 1982; Driver, et al. 1996; Heritage North 2004).

Within the LAA, there have been systematic archaeological investigations at four sites (two prehistoric and two historic), less-intensive excavations at ten more sites (all prehistoric), and systematic surface collections from eight sites (Spurling 1980b; Alexander 1982).

5.2.2 Archaeological Predictive Modeling Results

The following text describes the outcome of the 2010 field testing of the predictive model developed and later revised by Millennia Research (2010a, 2010b) for the Project.

From an intended total of 90 survey transects, 86 transects were inspected during the 2010 field survey (Figure 5.5). Four transects (33, 73, 78, 89) could not be tested due to land-access restrictions. Within those transects or portions of transects that the Golder team had authorization to enter and conduct the field study, 5,165 subsurface tests were excavated within an area of 176 ha. Table 5.3 summarizes the level of effort for the 2010 field survey by transect, showing the total number of shovel tests and number of positive shovel tests (that is, tests where archaeological materials were found) by lands rated as having low, moderate, and high archaeological potential according to the model. Of these, 1,884 (36.5%) are in lands rated as having high potential, 1,763 (34.1%) are in moderate potential, and 1,518 (29.4%) tests are in low potential settings.

In addition, 545 predetermined shovel test locations were visually examined but not excavated due to the presence of micro-topographic attributes that crew leads believed to denote negligible or extremely low archaeological potential, such as a cobble “pavement” with no soil development, or low-lying settings covered by standing water. Of this total, 121 (22.2%) locations were originally rated by the archaeological potential model as having high archaeological potential, 89 (16.3%) were rated as having moderate potential, and 335 (61.5%) had low potential. Therefore, a total of 5,710 test locations (5,165 excavated + 545 unexcavated) are considered to have been adequately evaluated in 2010.

The results of the 2010 transect survey can be summarized as follows:

- A total of 5,165 shovel tests were excavated, more or less equally divided between low, moderate, and high potential areas.
- Seven shovel tests were positive for cultural materials; five of these were in high potential settings, two were in moderate potential, and no positive tests occurred in low potential settings.
- The seven positive tests within the 2010 transects were attributable to five prehistoric archaeological sites (three sites are in high potential lands, two are in moderate potential).
- Three of the positive tests occurred within a previously documented archaeological site (HbRg-5), and the remaining four positive tests represent discoveries of new sites.
- One site was found outside the 2010 survey transects (in a low potential setting).
- One non-protected historic artifact find was reported (in a moderate potential setting).

One historical artifact and a small assemblage of prehistoric lithic artifacts were encountered and collected during the 2010 transect survey. Descriptions of the archaeological sites discovered or revisited in 2010 are included among the site summaries in Appendix F.

Table 5.3: Summary of 2010 test results by potential class

Transect No.[a]	Low Potential		Moderate Potential		High Potential		Total	
	No. of ST	No. of Positive	No. of ST	No. of Positive	No. of ST	No. of Positive	No. of ST	No. of Positive
1	23	0	56	0	33	0	112	0
2	27	0	43	0	14	0	84	0
3	40	0	26	0	33	0	99	0
4	80	0	148	0	176	0	404	0
5	76	0	125	0	85	1	286	1
6	53	0	133	0	120	0	306	0
7	28	0	67	2	72	0	167	2
8	15	0	41	0	29	0	85	0
9	21	0	51	0	75	0	147	0
10	14	0	18	0	25	0	57	0
11	9	0	14	0	21	0	44	0
12	8	0	5	0	27	0	40	0
13	15	0	0	0	8	0	23	0
14	10	0	0	0	4	0	14	0
15	8	0	8	0	2	0	18	0
16	16	0	3	0	7	0	26	0
17	19	0	0	0	0	0	19	0
18	12	0	0	0	0	0	12	0
19	6	0	0	0	5	0	11	0
20	6	0	28	0	11	0	45	0
21	10	0	4	0	8	3	22	3
22	6	0	19	0	16	0	41	0
23	20	0	6	0	11	0	37	0
24	14	0	4	0	21	0	49	0
25	18	0	15	0	14	0	47	0
26	23	0	0	0	14	0	37	0
27	14	0	2	0	2	0	18	0
28	14	0	13	0	11	0	38	0
29	16	0	13	0	9	0	38	0
30	18	0	12	0	8	0	38	0
31	13	0	7	0	11	0	31	0
32	17	0	19	0	38	0	74	0
34	16	0	28	0	22	0	66	0
35	14	0	17	0	16	0	47	0
36	34	0	62	0	58	1	154	1
37	28	0	42	0	79	0	149	0

Transect No.[a]	Low Potential		Moderate Potential		High Potential		Total	
	No. of ST	No. of Positive	No. of ST	No. of Positive	No. of ST	No. of Positive	No. of ST	No. of Positive
38	23	0	9	0	18	0	50	0
39	13	0	43	0	31	0	87	0
40	3	0	0	0	0	0	3	0
41	1	0	0	0	0	0	1	0
42	9	0	17	0	21	0	47	0
43	15	0	15	0	17	0	47	0
44	9	0	4	0	2	0	15	0
45	18	0	0	0	0	0	18	0
46	9	0	0	0	0	0	9	0
47	11	0	0	0	3	0	14	0
48	18	0	0	0	0	0	18	0
49	21	0	27	0	19	0	67	0
50	30	0	65	0	29	0	124	0
51	8	0	27	0	19	0	54	0
52	38	0	41	0	34	0	113	0
53	26	0	76	0	37	0	139	0
54	7	0	13	0	34	0	54	0
55	49	0	45	0	38	0	132	0
56	19	0	44	0	36	0	99	0
57	27	0	56	0	38	0	121	0
58	19	0	8	0	12	0	39	0
59	18	0	19	0	26	0	63	0
60	8	0	2	0	21	0	31	0
61	10	0	14	0	18	0	42	0
62	20	0	1	0	0	0	21	0
63	12	0	0	0	0	0	12	0
64	12	0	16	0	38	0	66	0
65	23	0	22	0	26	0	71	0
66	21	0	4	0	19	0	44	0
67	4	0	13	0	18	0	35	0
68	7	0	27	0	5	0	39	0
69	13	0	0	0	0	0	13	0
70	2	0	0	0	5	0	7	0
71	12	0	23	0	7	0	42	0
72	12	0	0	0	5	0	17	0
74	6	0	6	0	8	0	20	0
75	32	0	42	0	84	0	158	0

Transect No.[a]	Low Potential		Moderate Potential		High Potential		Total	
	No. of ST	No. of Positive	No. of ST	No. of Positive	No. of ST	No. of Positive	No. of ST	No. of Positive
76	13	0	10	0	11	0	34	0
77	3	0	0	0	0	0	3	0
79	18	0	0	0	0	0	18	0
80	11	0	20	0	29	0	60	0
81	11	0	6	0	13	0	25	0
82	6	0	2	0	29	0	44	0
83	12	0	4	0	16	0	32	0
84	14	0	13	0	32	0	59	0
85	15	0	0	0	0	0	15	0
86	21	0	0	0	0	0	21	0
87	24	0	0	0	0	0	24	0
88	9	0	0	0	0	0	9	0
90	13	0	0	0	0	0	14	0
Total	**1,518**	**0**	**1,763**	**2**	**1,884**	**5**	**5,165**	**7**

NOTES:
[a] Grey-highlighted rows denote transects with positive test results
ST – shovel tests

Following systematic field testing, and in consultation with the BC Archaeology Branch, the Millennia Research model was revised to better reflect conditions observed in the field. Low elevation terraces with predicted high potential were downgraded to low potential based on their recent age. False high potential ratings for developed areas, such as roads and gravel pits, were corrected, and several other minor improvements were made, resulting in Version 2 of the model.

The performance of the revised predictive model can be evaluated using measures of effectiveness and efficiency. Effectiveness refers to the rate at which the model captures known archaeological sites. Efficiency refers to the amount of land the model requires to capture these known sites (BC Archaeology Branch 2009a).

Millennia Research's Site C predictive model (Version 2) estimated that 9% of the Project area has high archaeological potential, 14% has moderate potential, and 77% has low potential. Further, 72.5% of known archaeological sites were captured within the predicted high potential lands. An additional 17.6% fell within predicted moderate potential lands, and the remaining 9.9% fell within lands predicted to have low archaeological site potential.

The Kvamme's Gain statistic is used by the BC Archaeology Branch as a single measure of model performance. This statistic measures how well a model predicts archaeological site locations, compared to chance. The Kv Gain is calculated as 1- [% area / % known sites]. Following the 2010 model testing field work, the Kv Gain statistic for lands predicted to have high potential was 0.87. BC Archaeology Branch guidelines suggest that a highly efficient model would have a Kv gain of 0.90 or greater, and a moderately efficient model would have a Kv gain between 0.80 and 0.90 (BC Archaeology Branch 2009a). The 2011 and 2012 field results were not used in evaluating the efficiency and effectiveness of the model because the field testing sample was skewed in favour of high potential polygons.

The BC Archaeology Branch will accept high efficiency models that capture at least 70% of known archaeological sites in 10% of the land base or less, or moderate efficiency models that capture 70% or more of known archaeological sites in up to 20% of the land base, as long as the Kv gain is 0.80 or higher (BC Archaeology Branch 2009a). The Site C predictive model (Version 2) performance surpassed these benchmarks, and as a result it was used to identify areas for archaeological assessment during the 2011 and 2012 field programs.

5.2.3 Archaeological Overview Assessment Results

For the desktop review, the Provincial Heritage Register was accessed on September 12, 2012, to obtain information on previously recorded archaeological sites within each of the project components (Figure 5.15). The Project archaeological potential model was applied to the AOA areas, except where LiDAR coverage was not available at the time of the assessment. Where LiDAR was unavailable, archaeological potential was extrapolated for those areas using values from immediately adjacent areas. Table 5.4 indicates the area of each assessed project component and identifies the extent of the LiDAR data gaps where present.

Table 5.4: Archaeological overview assessment development area size and LiDAR coverage gaps

Component	Size (ha)	LiDAR Gap (ha)	LiDAR Gap (% of total)
Dam site adjacent construction areas	2,040	-	-
Wuthrich Quarry	18	-	-
West Pine Quarry	104	0.002	0.002
Portage Mountain	148	6.81	5.49
Del Rio Pit	135	-	-
Area E	80	-	-

5.2.3.1 As Yet Undefined Construction Activity Areas Near the Dam Site

The as yet undefined construction activity areas near the dam site consist of six separate polygons surrounding the confluence of the Peace and Moberly rivers (Figures 5.6 and 5.7). These polygons exist above the reservoir flood line, beyond the original dam site footprint which has been subject to an archaeological inventory, and excludes areas that have been recently assessed (e.g., the transmission line corridor through the dam site adjacent construction areas).

There are 11 previously recorded archaeological sites within the as yet undefined construction activity areas near the dam site and several other sites in the immediate area. The sites within the as yet undefined construction activity areas near the dam site are summarized below. Unless otherwise noted, the summary information is derived from a *B.C. Archaeological Site Inventory Form* for the site in question.

HbRf-25 is a 200 m by 50 m surface lithic artifact scatter located near John Beatton's homestead cabin, on the north side of the Peace River on the upper terrace, opposite the confluence of the Peace and Moberly rivers. Originally recorded in 1974, HbRf-25 was revisited in 1978 by archaeologists from SFU, at which time 38 chert flakes (eight retouched), eight chert cores, 10 quartzite spalls, one hammer stone, and one adze were observed. The artifacts were not collected. A small portion of the south boundary of HbRf-25 is located within the as yet undefined construction activity areas near the dam site.

HbRf-27 is located south of Fort St. John on the north (left) bank of the Peace River. The site is a surface lithic artifact scatter found within a cleared field used for pasture. The site was recorded in 1977 by archaeologists from SFU, and five chert flakes were observed.

HbRf-28 is a surface lithic artifact scatter located in a cleared field, 20 m from the edge of a bluff, located south of Fort St. John on the north bank of the Peace River. The site was recorded in 1974 by archaeologists from SFU. Two chert flakes were observed, but not collected.

HbRf-41 was originally recorded in 1976 by archaeologists from SFU as a surface lithic artifact scatter. HbRf-41 is located on the second terrace above the floodplain on the south shore of the Peace River overlooking the confluence of the Peace and Moberly rivers. Two black chert flakes were observed at the site, one flake located on the erosional slope and one within an excavated unit. The artifacts were not collected. In 1977, the site was revisited and three black chert flakes were found in an exposed road cut (Fedje 1977). A brief surface reconnaissance in 1979 failed to locate additional artifacts (Wilson 1979).

HbRf-43 is a surface and subsurface artifact scatter on the south (right) bank of the Peace River, on a ridge break of the upper terrace, east of the Moberly River. The site was first discovered in 1977 where agricultural disturbances unearthed 20 black chert flakes (Fedje 1977). A site revisit in 1979 found a further 20+ black chert flakes, a black chert projectile point, and a grey gunflint (Wilson 1979). Wilson (1979) indicated the gunflint could be contemporaneous with site HbRf-31 (Rocky Mountain Fort, also known as Yale's House or MacIntosh's Post), located less than 4 km away, but this hypothesis has never been substantiated through further research and analysis.

HbRf-46 consists of a surface lithic artifact scatter consisting of three black chert flakes collected from a tractor cut along the BC Hydro transmission line right-of-way (Fedje 1977). The site is located on the uppermost terrace southeast of the confluence of the Peace and Moberly rivers. The dimensions of the site are not known, and it does not appear as though subsurface testing occurred in the area.

HbRf-47 is a surface lithic artifact scatter characterized by three artifacts found within a tractor cut on the upper terrace southeast of the confluence of the Peace and Moberly rivers. HbRf-47 was identified in 1977 during the assessment of a BC Hydro transmission line (Fedje 1977). No records are available that provide an indication of site dimensions or depth. Subsurface testing has not occurred in the area.

HbRf-90 is a subsurface lithic artifact scatter recorded by Golder (2011), measuring 15 m by 14 m. HbRf-90 is located atop a small knoll adjacent to the southeast side of the South Bank Access Road, 900 m northeast of the 8 km mark. Nine black chert flake fragments and one piece of black chert debitage were collected.

HbRf-91 is a subsurface lithic artifact site located on a semicircular hummock on the upper terrace on the south side of the confluence between the Peace and Moberly rivers, approximately 2.8 km south-southwest of the Peace River. Recorded in 2010 (Golder 2011b), the site is thought to measure 30 m by 25 m based on the extent of the micro-topographic landform the site is situated upon. Two artifacts were collected from this site; one blue grey chert scraper and one piece of black chert debitage.

HbRf-96 is situated on a large, forested, crescent-shaped terrace immediately above and south of the confluence of the Peace and Moberly rivers and is located on the boundary of the as yet undefined construction activity areas near the dam site. The site was discovered and recorded in 2011 and consists of a subsurface lithic artifact deposit found during subsurface testing (Golder and AMEC 2011). Three pieces of black chert shatter and two black chert flakes were collected.

HbRf-106 is situated on the north (left) bank of the Peace River near the edge of the high plateau above the river valley and spans the boundary of the as yet undefined construction activity areas near the dam site. The site is a surface and subsurface lithic artifact deposit found in association with a conveyor belt system for dam construction. Three artifacts were observed and collected from the surface, including two pieces of chert shatter and a medium to large chert cortical flake; a possible chert core tool, as well as a chert split-cobble core were also observed, but it is possible that the latter two artifacts were accidentally created by machine-traffic. The subsurface finds consist of two pieces of chert shatter, one found 5 cm below surface and the other at 15 cm below surface.

The results of the application of Millennia's archaeological predictive model to the as yet undefined construction activity areas near the dam site are summarized in Table 5.5.

Table 5.5: As yet undefined construction activity areas near the dam site archaeological potential

Development Area	Archaeological Potential	Area (ha)	Area (%)
As yet undefined construction activity areas near the dam site	High	330	16
	Moderate	92	5
	Low	1618	79

Previously recorded archaeological sites in the as yet undefined construction activity areas near the dam site generally consist of low-to-medium-density lithic artifact scatters. Assemblages are dominated with black chert debitage, but some ground stone tools and quartzite objects are also present in lower frequencies. At least one site, HbRf-43, contains a historic artifact (gunflint). It is anticipated that similar, low-density lithic scatter sites exist in unsurveyed portions of the as yet undefined construction activity areas near the dam site.

5.2.3.2 Wuthrich Quarry

The Wuthrich Quarry is approximately 18 ha and is situated atop, and surrounding, a break-in-slope associated with an exposed sandstone bedrock outcrop located approximately 275 m east of Charlie Lake and 2.5 km north of the Alaska Highway (Figure 5.8). Available mapping indicates undeveloped areas exist beyond the footprint of an existing quarry and are largely forested with poplar and surrounded by farmland and recreational properties associated with Charlie Lake. The active quarry area has been disturbed by past extraction activities.

Previous archaeological assessment in the area includes an archaeological site inventory for a proposed Ministry of Transportation and Highways rock quarry (Walde 1989), and two AIAs for residential subdivisions along the shore of Charlie Lake (Walde 1995; Low, et al. 1998). Although the report by Walde (1989) addresses a substantial portion of the Wuthrich Quarry, it does not meet the data requirements of the Site C Project.

There are eight previously recorded archaeological sites in the vicinity of the Wuthrich Quarry, one of which is within the development area and another which is in close proximity. The remaining six sites are located along the shores of Charlie Lake and are not discussed further due to their location outside the LAA. Unless otherwise noted, the summary information is derived from a *BC Archaeological Site Inventory Form* for the site in question.

HbRf-70 is located within the Wuthrich Quarry area. The site is described as a subsurface lithic artifact scatter situated on level terrain below an exposed sandstone rock outcrop (Walde 1989). HbRf-70 was declared a Legacy Site[5] in 1995 after being destroyed by the quarry operation. Walde (1989) postulates that the sandstone outcrop and the terrain above it may have been used as an animal run and associated jump. However, archaeological evidence supporting this assertion has not been found.

HbRf-71 is a surface stone artifact scatter consisting of black chert debitage and a single bone fragment situated 263 m east of the development boundary. The site is located on the north side of a break in slope at the edge of a shallow drainage near the top of a prominent east–west trending ridge (Walde 1989).

The results of the application of the Project archaeological potential model to the Wuthrich Quarry area are summarized in Table 5.6.

Table 5.6: Wuthrich Quarry archaeological potential

Development Area	Archaeological Potential	Area (ha)	Area (%)
Wuthrich Quarry	High	0.6	3.4
	Moderate	1.3	7.2
	Low	16.1	89.4

Previously recorded archaeological sites in the Wuthrich Quarry and surrounding area generally consist of low-density lithic artifact scatters associated with a prominent bedrock outcrop or the shores of Charlie Lake. Assemblages are dominated with black chert, but also contain bone fragments. It is anticipated that stone artifact sites exist in unsurveyed portions of the Wuthrich Quarry. However, there is potential for rock overhangs and caves that could contain very old, stratified, archaeological sites similar to the nearby Charlie Lake cave site (HbRf-39).

Portions of the Wuthrich Quarry contain disturbed areas associated with previous development; it is unlikely that these areas contain archaeological remains, and they are identified as areas of low archaeological potential by the Site C Clean Energy Project archaeological potential model. However, less disturbed portions of the Wuthrich Quarry are identified as having areas of moderate and high archaeological potential because of the close proximity of Charlie Lake and known archaeological sites, and the presence of several rock overhangs below the leading edge of the sandstone bluff.

5.2.3.3 West Pine Quarry

The West Pine Quarry is approximately 104 ha and is situated in the Hart Ranges of the Rocky Mountains, approximately 100 m north of the Pine River along Highway 97, and 1.9 km west-northwest of Hart Lake (Figure 5.9). The quarry is characterized by steeply sloping, mountainous terrain. Much of the development area is forested; however, a portion of the area has been disturbed by an existing quarry operation and a railway right-of-way that travels along the south boundary of the quarry.

[5] A legacy site is an archaeological site that remains in the Provincial Heritage Register, but it is not subject to protection under the British Columbia *Heritage Conservation Act*, usually because of development related disturbances that remove all traces of archaeological deposits.

There are no previously recorded archaeological sites within 5 km of the West Pine Quarry area. The results of the application of the Project archaeological potential model to the proposed West Pine Quarry area are summarized in Table 5.7.

Table 5.7: West Pine Quarry archaeological potential

Development Area	Archaeological Potential	Area (ha)	Area (%)
West Pine Quarry	High	3.52	1.5
	Moderate	1.38	3.5
	Low	99.10	95

LiDAR maps show that within the West Pine Quarry area, portions of a terrace associated with the Pine River may remain relatively intact. Two unnamed drainages, both with small wetland areas, flow through the centre portion of the proposed quarry and the model shows features associated with these drainages have archaeological potential. Level terrain associated with the top of two north–south trending ridges in the north-central portion of the development area are identified as areas of high archaeological potential as the ridges provide a potential travel corridor and possibly vantage points over the river valley. In addition, the south boundary of the West Pine Quarry is situated adjacent to the Pine River and also contains areas of moderate and high archaeological potential.

Considering the mountainous environment and short summer season, along with regional archeological culture typologies, expected archaeological site types in the vicinity of the West Pine Quarry include trails, culturally modified trees, and small seasonally occupied campsites or resources procurement sites that would typically contain chipped stone artifacts and possibly bone.

5.2.3.4 Portage Mountain Quarry

The Portage Mountain source area is approximately 148 ha and situated on the southeast side of Portage Mountain, overlooking the Dinosaur Reservoir located approximately 1.3 km to the southeast (Figure 5.10). The lower elevation portions of Portage Mountain are situated mostly within existing forestry cut blocks, whereas the higher elevation portions are forested. The majority of Portage Mountain is characterized by exposed bedrock outcrops, sheer cliffs, and steeply sloping terrain.

There are no previously recorded archaeological sites within the Portage Mountain source area. Background research did not result in the identification of previous archaeological studies beyond those conducted in relation to the Project by Golder (Golder 2012). Specifically, Golder conducted a reconnaissance and a subsequent AIA of engineering-related developments in the south portion of the Portage Mountain area. For this work, areas of archaeological potential overlapping with geological drill locations were tested and other areas with archaeological potential were observed beyond currently developments. Observed areas of archaeological potential include vantage points and several rock overhangs that may have been suitable for human habitation.

The results of the application of the archaeological potential model to the Portage Mountain source area are summarized in Table 5.8.

Table 5.8: Portage Mountain archaeological potential

Development Area	Archaeological Potential	Area (ha)	Area (%)
Portage Mountain Quarry	High	6	4
	Moderate	5.91	4
	Low	136.33	92

Archaeological fieldwork in the area undertaken by Golder (2012) identified several rock overhangs and crevices that may have been suitable for human habitation. In the higher elevation portions of Portage Mountain, several small ponds and associated wetlands are present. The elevated and well-drained terrain surrounding these areas has archaeological potential for small stone artifact scatters or trails. An unnamed drainage flows through the north half of the Portage Mountain source area, and further into Dinosaur Reservoir. This drainage has well-defined banks and terraces at lower elevations that have areas of moderate and high archaeological potential associated with them.

In addition, the portions of Portage Mountain that are situated upon relatively level terrain in close proximity to bluff edges are identified as areas of high archaeological potential because of the vantages and lookout points that they offer. The level terrain behind the bluff edges could contain seasonally occupied sites composed of low-to-medium-density lithic artifact scatters.

Considering the subterranean nature of the observed rock overhangs and crevices and the archaeological potential model's limitations for identifying these features, the model should not be solely relied upon for determining archaeological potential in this area. Considering the mountainous environment and short summer season, along with regional archeological culture typologies, expected archaeological site types in the vicinity of the Portage Mountain source area include trails, culturally modified trees, and small seasonally occupied campsites or resource procurement sites that would typically contain chipped stone artifacts and possibly bone.

5.2.3.5 Del Rio Pit

The entire Del Rio Pit measures 162 ha. However, Del Rio is bisected by an existing BC Hydro transmission line right-of-way and is included in the Project's transmission line, both of which have been excluded from the Del Rio Pit AOA study area. This exclusion resulted in the creation of two separate polygons and reduced the assessment area to 135 ha (Figure 5.11). The pit is located inland, on the uplands approximately 17 km southeast of the Peace River, 3 km southeast of the Moberly River, and 2.75 km northwest of Windy Creek.

Previous archaeological assessments in the area include a reconnaissance and AIA associated with the existing transmission line (Fedje and Spurling 1977; Wilson 1979) and an AIA of a portion of the Del Rio Pit on behalf of the BC Ministry of Transportation (Downey, et al. 2011). Most recently, as part of the current study, an AIA was completed adjacent to the existing BC Hydro transmission line right-of-way that passes through the Del Rio Pit.

There is one previously recorded archaeological site within the Del Rio Pit. This site is summarized below.

HaRi-1 is a surface lithic artifact scatter characterized by two stone artifacts found on the southeast side of an exposure associated with a slightly raised section of an existing road. The site was identified by Fedje (1977) during the assessment of the existing BC Hydro transmission line. Observed artifacts consist of a large, black chert side-notched projectile point and a black chert core. An AIA conducted by Ecofor that focused subsurface testing in a portion of the Del Rio Pit determined that HaRi-1 was mis-plotted in the Provincial Heritage Register by comparing GPS coordinates and flagging found in the field. Ecofor updated the site location in the Provincial Heritage Register, but no subsurface testing was conducted at the site during the Ecofor work (Downey, et al. 2011). The areal extent of the site remains unknown.

The results of the application of the Project archaeological potential model to the Del Rio Pit area are summarized in Table 5.9.

Table 5.9: Del Rio Pit archaeological potential

Development Area	Archaeological Potential	Area (ha)	Area (%)
Del Rio Pit	High	7.9	5
	Moderate	10.1	6
	Low	143.54	89

Based on a review of available mapping and previous consultant reports, the Del Rio Pit is located in an area with numerous micro-topographic features that have archaeological potential. LiDAR mapping and the potential model indicate that linear ridges, knolls, and other examples of slightly elevated terrain are located throughout the development area. There are no drainages of note in the immediate area; the closest named stream is Windy Creek, and the Moberly River is approximately 3 km distant. However, a small unnamed kettle lake is situated approximately 500 m southwest of the southwest boundary. Considering that known archaeological sites exist on similar landforms described above, and that one known archaeological site is located within the development area, portions of the Del Rio Pit have moderate and high archaeological potential. Expected archaeological site types include trails, culturally modified trees, and small seasonally occupied campsites and resources procurement sites that would typically contain chipped stone artifacts and possibly bone.

5.2.3.6 Area E

The Area E contingency gravel pit is 80 ha in size and situated approximately 1 km north of the confluence of the Peace and Pine rivers on the south (right) bank of the Peace River (Figure 5.12). Area E is bounded to the east by an existing gravel pit and railway right-of-way. Previous archaeological assessments in the vicinity are limited to an AIA conducted on the proposed B.C. Ministry of Transportation Teko Gravel Pit Expansion by Heritage North (Hutchings 2000). The study area for the Teko Pit is situated surrounding the north and east boundary of Area E, on the opposite side of the railway tracks to the southeast and does not overlap with Area E. There are no previously recorded archaeological sites within Area E.

The results of the application of the Project archaeological potential model to Area E are summarized in Table 5.10.

Table 5.10: Area E archaeological potential

Development Area	Archaeological Potential	Area (ha)	Area (%)
Area E	High	1.5	2
	Moderate	8.5	10
	Low	70	88

Area E is situated on a low-to-intermediate terrace of the Peace River, upstream of the confluence of the Peace and Pine rivers. The majority of Area E has been deforested and is currently being used for agricultural purposes. The leading edge of the terrace is within Area E and trends southeast-northwest along the northeast boundary. Terrain behind the terrace edge is level and contains areas of moderate and high archaeological potential. Some areas of micro-topographic relief that have moderate archaeological potential are located in the centre portion of Area E. A large disturbed area, associated with the nearby railway and siding, is situated directly southeast of Area E. Considering that the development is situated on an intermediate terrace of the Peace River near the confluence of a major tributary drainage, there is potential to find large archaeological sites that could contain features, chipped and ground stone artifacts, along with faunal remains. Other smaller and low-to-medium-density lithic scatters are also anticipated site types in this area. Both types of sites are more likely to occur near the edge of the terrace, corresponding to the areas identified as having moderate and high archaeological potential by the archaeological potential model.

5.2.3.7 Recommendations

The general recommendations stemming from the AOA of the as yet undefined construction activity areas near the dam site and construction materials source locations are similar across the developments. In addition to general recommendations, project-specific recommendations are also provided.

Considering that each development component assessed has areas of moderate and high archaeological potential within it, as defined by the Project archaeological predictive model, an archaeological impact assessment of these areas is recommended. The AIA should follow the methods outlined in HCA Permit 2010-0378. In addition, during the AIA, judgemental subsurface testing of additional high potential areas not identified by the model, such as rock overhangs, vantage points, and subtle landscape features situated on macro-topographic features (e.g., the centre portion of a large terrace) is recommended.

Previously recorded archaeological sites located within and directly adjacent to the development areas should be revisited to confirm their extent (i.e., delineate area, depth, condition, contents, status), assess site significance (see BC Archaeology Branch 1998), determine potential project effects and formulate appropriate site-specific management recommendations.

As part of the AIA for the Del Rio Pit and Wuthrich Quarry, it is recommended that observed subsurface test locations conducted during previous archaeological assessments by other consultants be spatially recorded and added to the Project database of subsurface test locations, where appropriate, to avoid duplication of effort.

5.2.4 Archaeological Field Results

During 2010 archaeological field work focused on testing Millennia Research's (2010a) predictive model. Field work in 2011 and 2012 involved a systematic site inventory within the heritage resources LAA.

Figures 5.13, 5.14, and 5.15 show the extent of survey coverage in 2011 and 2012, as well as subsurface test locations, and all documented archaeological sites in the heritage resources LAA. Figures 5.16.1 through 5.16.241 provide site-specific information, including archaeological site potential ratings, subsurface test results, and archaeological site boundaries. Detailed site descriptions are found in Appendix F for all sites in the LAA, except 10 sites located in Project components that have not yet been assessed by the field program since development plans are not adequately advanced to allow for a thorough assessment. Historical archaeological sites, including those protected by the B.C. *Heritage Conservation Act*, are described in Section 6 of this report.

Within the lands inspected for the Project, a total of 57,272 subsurface test locations were examined from 2010 to 2012. Of these, 5,165 were excavated within transects run for evaluation of the Millennia Research (2010a) predictive model. During the 2011 and 2012 field seasons, 52,107 subsurface tests locations were examined, including the excavation of 31,672 grid tests, 7,815 adaptive tests, and 6,986 judgemental tests. The remainder of tests include evaluative units, auger, and backhoe tests completed as part of the deep testing program, and "no tests," which are grid tests that could not be completed due to significant ground disturbance observed at the test location, a limiting environmental constraint such as inundated or water saturated lands, or are located within the previously cleared portion of the existing transmission corridor (IL374).

Prior to the assessment, 111 archaeological sites had been recorded in the heritage resources LAA, including previously recorded sites located on private lands to which access was denied during the field inventory. During the assessment, 140 additional archaeological sites were identified. Archaeological sites were identified in all assessed Project components. Post-field analysis resulted in some sites being combined due to their proximity and similarity. Following analysis, 251 archaeological sites have been documented within the LAA (Figure 5.15). Of these, 184 are low density lithic scatters with less than 100 artifacts, typically containing only artifacts made from black chert, including 57 sites where only a single artifact has been located. Table 5.11 summarizes archaeological site frequencies by Project component. The total number of sites exceeds the actual total, because many sites are found within the footprint of two or more Project components.

Table 5.11: Archaeological sites by project component

Project Component	Total Area (ha)	Sites Recorded before 2011	Sites Recorded 2011-2012
Dam and generating station	2035.17	13	25
Reservoir	9,614.52	85	78
Transmission Line	1.378.37	3	25
Highway 29 Realignment	539.39	29	18
Quarried and Excavated Material Source	496.04	48	44

Table 5.12 summarizes 241 sites found within the LAA by archaeological potential rating. Ten sites which fall outside of areas assessed in 2010 through 2012 have been excluded from the table. These include one site within the dam and generating station, two sites on access roads, and seven sites within quarried and excavated construction materials areas.

Table 5.12: Archaeological sites by archaeological potential rating

Potential Rating	Number of archaeological sites	
	Frequency	Per Cent
High[a]	185	76.8
Moderate	24	17.02
Low	32	22.7
Totals	241	100%

NOTES:
[a] An archaeological site may be located on lands with more than one potential rating. If any portion of a site is located on lands rated as high potential, the entire site area is included under "high."

5.2.4.1 Archaeological Inventory Surveys – 2010 to 2012 Summary

Table 5.13 summarizes the results of the field surveys in 2011 and 2012, broken down by Project component and modeled archaeological potential rating. This table also shows the frequency and identifies the setting by Project component for subsurface tests excavated during the 2010 transect surveys. As suggested above, the quoted frequencies exceed the actual total number of tests that were excavated, because every assessed Project component overlaps the footprint of neighbouring components.

Table 5.13:Summary of 2010, 2011 and 2012 archaeological fieldwork effort

Project Component	Modeled Archaeological Potential	Total Area (ha)[a]	Area Surveyed (ha)	No. of 2010 Transect Tests	No. of Grid Tests	No. of Adaptive Tests	No. of Judgemental Tests	Total No. of Tests (Modeled Potential)	Total No. of Tests (Component)
Dam and generating station	High	232.02	147.69	397	9,915	335	293	10,940	14,001
	Moderate	208.49	114.43	590	217	132	480	1,419	
	Low	1,395.23	497.32	492	156	144	850	1,642	
Reservoir	High	177.08	194.52	361	10,913	2,028	898	14,200	26,518
	Moderate	339.63	185.74	974	427	610	1,278	3,289	
	Low	5,329.22	1,569.57	4,467	948	1,335	2,279	9,029	
Transmission Line	High	117.42	99.84	15	5,951	607	232	6,805	7,900
	Moderate	52.61	24.22	4	4	3	0	11	
	Low	1,224.42	522.67	11	56	486	531	1,084	
Highway 29 Realignment	High	56.49	39.00	1	2,444	995	126	3,566	5,022
	Moderate	126.64	47.88	24	47	453	360	884	
	Low	218.71	94.75	77	166	188	141	572	
Quarried and Excavated Material Source	High	103.63	92.14	183	4,458	1,440	718	6,799	10,123
	Moderate	150.97	76.93	202	132	331	580	1,245	
	Low	1,314.11	425.07	278	260	616	925	2,079	

NOTES:
[a] Dam and generating station = 2,035.16 ha; reservoir = 9620.89 ha; transmission line = 1,399.57 ha; Highway 29 re-alignment = 417.97 ha; quarried and excavated material sources = 1,568.71 ha.
[b] Values for reservoir survey coverage exceed total area of Project component as presently defined because lands above the reservoir were inspected during the 2011 field program.

5.2.4.2 Summary of Results by Method

As described in Section 5.1.5, various methods were employed to identify and record archaeological sites in the heritage resources LAA. The results associated with each of these methods are described below.

5.2.4.2.1 Systematic Survey with Subsurface Testing

Systematic survey sampling explored lands rated as having high archaeological potential by the archaeological predictive model. Based on the model, there were 40,594 pre-programed grid test locations within the lands covered by the 2011 and 2012 heritage program. Of this total, 29,461 locations (72.57% of the total) were excavated within Project lands accessible in 2011 and 2012. Of the 29,461 grid tests that were excavated, 324 (1.09%) were positive for archaeological materials. In addition to the excavated grid tests, 5,356 “no tests” were recorded, representing grid tests that were abandoned due to significant ground disturbance observed at a test location, limiting landscape features such as beaver dams or wetlands, or were located along previously cleared portions of an existing transmission line (IL374) that was excluded from the survey area. Table 5.14 summarizes the results of the grid testing in 2011 and 2012. The total number of tests shown in the table exceeds the actual number of excavated grid tests, as many of the tests are located in two, or more, components.

Table 5.14: Summary of 2011 and 2012 systematic subsurface grid testing

Project Component	Theoretical Total of Tests[a]	Tests Excavated	Positive Tests	Negative Tests	Abandoned Grid Tests (No Tests)	Tests within Revisited Sites	Tests within New Sites
Dam and generating station	12,811	10,288	40	10,248	701	303	102
Reservoir	16,017	12,288	170	12,118	1,326	1,506	10,786
Transmission Line	8,619	6,010	35	5,976	2,718	7	138
Highway 29 Realignment	4,472	2,657	78	2,579	454	437	156
Quarried and Excavated Material Source	6,814	4,850	94	4,756	861	544	156

NOTES:
[a] Denotes number of tests predicted for high potential lands by GIS model and pre-programed tests in documented sites.

Grid tests were excavated within lands rated as having moderate (n = 532) or low (n = 1,192) potential by the archaeological predictive model, although the systematic testing strategy was explicitly intended to inspect high potential settings. There are two reasons for this: 1) in 2011, a cluster of eight systematic tests was programed for each “small landform” feature identified by the LiDAR mapping, as described in Section 5.1.5.4 and 2) systematic tests were programed within polygons conforming to the reported dimensions of previously recorded archaeological sites, including those situated within lands rated as having low or moderate potential by the predictive model.

5.2.4.2.2 Systematic Surface Inspection

Surface inspection was conducted on an ongoing basis during the field surveys. For example, field crew members scanned the surface when proceeding to and from targeted testing locations, and between subsurface test locations. Although the primary intent of this action was to identify artifacts exposed on the surface, it was also an effective way of determining if archaeological features (e.g., CMTs, depressions) and historical remains were present.Systematic surface inspection was adopted when un-vegetated open settings were encountered, most often cultivated or fallow fields, but also including terrace margins influenced by wind-deflation. Systematic inspection of an exposed soil surface provides a good impression of the extent of archaeological remains where present, as well as the density and diversity of cultural materials. As described in Section 5.1.5.4, this procedure was not restricted to lands rated as exhibiting high archaeological potential in the predictive model. Furthermore, implementation of surface inspection did not preclude the need for subsurface testing at that location. At the beginning of the 2011 field season, surface inspection was conducted prior to issuance of the amended BC *Heritage Conservation Act* permit by the BC Archaeology Branch. No artifact collection or subsurface testing was conducted at that time, but surface find locations were recorded. Although all efforts to return to these surface finds were made, some could not be revisited to due to the fields being covered by crops for the remainder of the season. No systematic surface inspections were conducted during the 2012 field program as ground conditions in cultivated fields were not conducive for effective surface inspection. These areas were subject to systematic survey with subsurface testing as described above.

The areas covered by surface inspections during the 2011 and 2012 field programs are portrayed on Figures 5.13.1 to 5.13.31 Table 5.15, summarizes the areal extent of surface inspections by Project component and archaeological potential.

Table 5.15: Summary of area covered by surface inspection in 2011 and 2012

Project Component	Potential Rating	Area Surveyed (ha)	Total Area (ha)
Dam and Generating Station	High	147.69	759.43
	Moderate	114.43	
	Low	497.32	
Reservoir	High	194.52	1,949.82
	Moderate	185.74	
	Low	1,569.57	
Transmission Line	High	99.84	646.73
	Moderate	24.22	
	Low	522.67	
Highway 29 Realignment	High	39.00	181.62
	Moderate	47.88	
	Low	94.75	
Quarried and Excavated Material Source	High	92.14	594.15
	Moderate	76.93	
	Low	425.07	

5.2.4.2.3 Judgemental Survey

As described in Section 5.1.5.5, judgmental testing was undertaken at the discretion of crew leads, principally to examine settings which exhibited micro-topographic characters that favour the distribution of archaeological sites in the LAA. Judgmental survey and testing occurred in areas shown in Figure 5.13.

Crews also excavated judgemental tests in areas of high potential where the 12 metre grid test interval was suspected to be too wide to result in the discovery of buried archaeological remains in particular settings. Lastly, judgemental testing was also proposed as part of the wetlands investigation and Rocky Mountain Fort exploration strategies, as described below.

Table 5.16 summarizes judgemental testing data collected during the 2011 and 2012 field surveys. A total of 6,986 judgemental tests were excavated over the two seasons, of which 6,698 were negative and 288 were positive (4.12%). The total numbers of tests shown in the table exceed the actual number of excavated judgemental tests, as many of the tests are located in two, or more, Project components.

Table 5.16: Summary of 2011 and 2012 judgemental testing

Project Component	Tests Excavated	Positive Tests	Negative Tests	Tests within Revisited Sites	Tests within New Sites
Dam and Generating Station	1,630	27	1,596	152	68
Reservoir	4,455	137	4,319	626	4,012
Transmission Line	763	49	714	1	379
Highway 29 Realignment	627	65	573	232	95
Quarried and Excavated Material Source	2,223	69	2,166	433	295

5.2.4.2.4 Adaptive Testing

Adaptive testing was implemented when positive subsurface test results signified the discovery of an archaeological site. The purpose of this adaptive testing was to identify the horizontal (length and width) and vertical (depth below surface) parameters of a site.

The number and placement of adaptive tests was usually dictated by landform constraints, but always took place at intervals of two metres on cardinal vectors from the previous positive test location. Adaptive testing ceased when at least two negative tests were excavated from the last positive test, or when the limits of a discrete landform (e.g., terrace margin, river bank) or study boundary were reached.

A total of 7,815 adaptive tests were excavated. Of these, 6,144 were negative and 1,671 were positive, representing 20.69% of the total. Table 5.17 summarizes the 2011 and 2012 adaptive testing. The total number of tests shown in the table exceeds the actual number of excavated adaptive tests, as many of the tests are located in two, or more, components.

Table 5.17: Summary of 2011 and 2012 adaptive testing

Project Component	Tests Excavated	Positive Tests	Negative Tests	Tests within Revisited Sites	Tests within New Sites
Dam and Generating Station	611	66	545	19	429
Reservoir	3,973	816	3,157	1,772	375
Transmission Line	1,096	287	809	12	1,036
Highway 29 Realignment	1,636	377	1,259	1,045	577
Quarried and Excavated Material Source	2,382	457	1,930	1,095	1,262

5.2.4.2.5 Evaluative Testing

Evaluative testing was completed at the discretion of individual Crew Leads and by direction of the Field Program Manager. The purpose of the evaluative testing was to further refine the scientific significance assessment of an individual site, to gain additional detail about the subsurface stratigraphy at a site location, or to determine the level of past disturbance at a site location. In total, eight evaluative tests were completed during the 2011 and 2012 field seasons. All of the evaluative tests were completed within the boundaries of known archaeological sites and all were positive for archaeological remains. Evaluative testing was rarely required given the intensive adaptive testing employed at each site. It was primarily used where clarity was sought on the possibility of multiple occupation levels.

5.2.4.2.6 Deep Testing

Millennia Research's archaeological predictive model identified over 60 land polygons (approximately 106 hectares) within the Peace River valley where sedimentary environments suitable for stratified archaeological deposits are present. These polygons are portrayed on Figure 5.17. Between the 2011 and 2012 field seasons, some of these parcels were eliminated or reduced in area when the LAA was re-defined. However, based upon a review of Crew Leads' field observations and other data, a number of new locations were identified as a focus for deep testing.

The purpose of the deep testing strategy was to explore settings with deep accumulations of sediments, in which archaeological remains could be buried at depths greater than could be reached by shovel testing. Potential dune fields and alluvial fans identified by LiDAR mapping were among the targets recommended for deep testing, including dune fields near a concentration of archaeological sites at the Watson Slough locality, and individual sites where Crew Leads observed what they thought could be evidence of buried palaeosols. In total, nine locations were tested for deeply buried archaeological materials (Figure 5.17). Each of these areas is summarized below.

5.2.4.2.7 Deep Test Location 1: Section 9, Township 84, Range 21

Stage one pre-screening at deep test location 1 consisted of four shovel tests and two combination shovel and auger tests, judgementally excavated on a slight rise at the edge of a terrace overlooking the Peace River. Three tests were excavated within archaeological site HbRh-122 and three tests were excavated within archaeological site HbRh-124. The vertical extent of the shovel tests ranged from a minimum of 30 centimetres to a maximum of 74 centimetres and the two shovel-auger tests extended to 110 centimetres and 116 centimetres below surface. The shovel tests and one shovel-auger test were discontinued due to the presence of large rocks at the base of each test which inhibited continued excavation. The remaining shovel – auger test was discontinued due to the presence of loose, fine sand that could not be retrieved by the bucket auger. The stratigraphy was consistent for all tests: dark yellowish-brown, loamy sand overlying yellowish-brown sand-to-fine sand overlying brown fine sand mixed with boulders. Two pieces of debitage were recovered at a depth of 25 centimetres from a shovel test within site HbRh-122. One piece of grey chert shatter was recovered at a depth of 40 centimetres from a shovel – auger test within HbRh-124. These results are not unexpected as the tests are located within the recorded boundaries of existing archaeological sites. No evidence of buried soil horizons or archaeological features was observed. The stratigraphic variation observed within the six tests is consistent with what would be expected in the context of an alluvial fan depositional environment and no deeply buried archaeological materials are expected at this location. Based on the results of stage one pre-screening, no mechanical deep testing was conducted at this location.

5.2.4.2.8 Deep Test Location 2: Section 4, Township 84, Range 21

Stage one pre-screening at deep test location 2 consisted of four shovel tests, judgementally excavated within archaeological site HbRh-125. The tests ranged in depth from 44 to 55 centimetres below surface and the observed stratigraphy was generally similar between the tests: dark, yellowish-brown loamy sand overlying yellowish-brown sand-to-fine sand overlying brown, fine sand mixed with boulders. No evidence of buried soil horizons or archaeological features was observed and no archaeological materials were recovered. The stratigraphic variations observed within the four tests are consistent with an alluvial fan deposit and no deeply buried archaeological materials are expected at this location. Based on the results of stage one pre-screening, no mechanical deep testing was conducted at this location.

5.2.4.2.9 Deep Test Location 3: Section 5, Township 84, Range 21

Stage one pre-screening at deep test location 3 consisted of six combination shovel and auger tests judgementally excavated within site HbRh-36. The tests were excavated by shovel to depths of approximately 100 centimetres and then extended by use of a bucket auger to depths ranging from 142 to 198 centimetres below surface. The depths of deposit encountered during the auger tests indicated that further testing was warranted. To that end, four trenches (trenches 1 to 4), measuring approximately 2.5 x 1.3 to 1.5 metres were excavated in dune features (stage two).

The observed stratigraphy was generally similar between the trenches, comprising five layers, as follows: approximately 20 to 30 centimetres of yellowish-brown to brown fine sand, overlying 40 to 70 centimetres of yellowish-brown sand to fine sand, overlying approximately 60 centimetres of light grayish-brown coarse sand

overlying 30 to 40 centimetres of coarse, very coarse, or mixed sand in colours subtly ranging from light brownish-grey to greyish-brown to dark grey. All of the trenches revealed a layer of boulders between approximately 160 and 170 centimetres below surface and the excavation was discontinued at this point.

Of the four trenches, only Trench 3 and Trench 4 were positive for archaeological materials. Three chert cores and 100 chert debitage elements were found at depths ranging from 0 to 50 centimetres below surface in trench 3. In trench 4, one piece of brown and black mottled chert was recovered between 0 and 10 centimetres below surface.

5.2.4.2.10 Deep Test Location 4: Section 32, Township 83, Range 21

At deep test location 4 five trenches were excavated within a large, open pasture with numerous dune deposits. Trench 6 was placed on top of a large dune overlooking the pasture. Trenches 7 and 9 were placed on saddles between smaller dunes, and trenches 8 and 10 were placed on low dunes within the bounds of archaeological site HbRh-8. The observed stratigraphy was generally similar between the trenches, comprising between 40 and 55 centimetres of mixed silts and sands, overlaying varying depths of sand to depths of between 110 and 200 centimetres, where the excavations bottomed on sand mixed with boulders and cobbles. The exceptions to this pattern were trench 6, where the sandy boulder and cobble sediments were not reached, and trench 9, where the sediments transitioned from mixed silts and sands, directly into the sand-boulder-cobble layer. No evidence of buried soil horizons or archaeological features was observed, and no archaeological materials were recovered.

5.2.4.2.11 Deep Test Location 5: Section 32, Township 83, Range 21

At deep test location 5, eleven trenches were excavated within, and adjacent to a large, open pasture with numerous dune deposits. Access to some locations was partially constrained by forest cover. Trenches 11, 13, and 14 were placed on a long, low dune, near archaeological site HbRh-112, while trench 12 was placed in the field, immediately to the south. Trenches 15 and 17 were placed on a rounded dune, north of HbRh-112. Trenches 16 and 19 were placed in swales between dunes, and trench 18 was placed on the slope of a dune. Trenches 20 and 21 were placed on a dune southwest of HbRh-65.

The observed stratigraphy was generally similar between the trenches, comprising between 30 and 80 centimetres of mixed silts and sands, overlaying varying depths of sand, up to 220 centimetres in depth, where the majority of these trench excavations bottomed on sand mixed with boulders and cobbles. Exceptions to this pattern were trench 12 where the upper silt layer transitioned immediately into silt and sand mixed with boulders and cobbles, and trench 15, where the sand – boulder – cobble sediments were not reached. Approximately eight black chert flakes and shatter fragments were found in the upper 20 centimetres of trench 13, northeast of HbRh-112. These artifacts are consistent with those found during the initial investigations at HbRh-112 and it is considered likely that this forms part of the same site. No evidence of buried soil horizons or archaeological features was observed, and no archaeological materials below 20 centimetres below surface were recovered.

The observed stratigraphy, with the lack of bedding planes and overall homogeneity within the various layers, supports an interpretation of windblown silts and sands rapidly forming into dunes over poorly sorted basal sediments. The lack of observed buried soil horizons, along with the consistent transition from sand, to sand and silt, is consistent with this interpretation of a windy, early post-glacial environment with minimal vegetation cover, allowing rapid accretion of wind-blown sand deposits, followed by a period of reduced deposition rate and smaller grain size, as ground cover was established.

5.2.4.2.12 Deep Test Location 6: Section 31, Township 83, Range 21

Two trenches were excavated at deep test location 6. Trench 4 was placed on a low saddle just north of a dune where archaeological site HbRh-5 is located. Trench 5 was placed on the top of the highest point of the dune, within HbRh-5. Within the access constraints dictated by forest cover, trenches were located to investigate the differences between the top and sides of the dune. The stratigraphy in trench 4 comprised 40 centimetres of mixed silt with a trace of sand, over silty sand mixed with boulders and cobbles and gravel. The stratigraphy in trench 5 comprised approximately 90 centimetres of silty sand, over sand with a trace of silt. No evidence of buried soil horizons or archaeological features was observed, and no archaeological materials were recovered.

5.2.4.2.13 Deep Test Location 7: Un-surveyed Crown Land

Pre-screening for deep testing consisted of three judgemental shovel tests that ranged in depth from 41 to 73 centimetres below surface. Each test was discontinued due to the presence of cobbles, which inhibited continued shovel testing, or the maximum reach of the shovel. Observed sediments ranged from grey to brown silt or silty-clay to fine sands. No evidence of buried soil horizons or archaeological features was observed, and no archaeological materials were recovered. The stratigraphic variations observed within the three shovel tests are consistent with what would be expected in the context of an alluvial fan environment. No deeply buried archaeological sites are expected at this location, due to the presence of a cobble layer observed in one of the tests and which are interpreted as a buried river bed, and clay deposits in another which are interpreted as glacial deposits. Based on the results of the stage one pre-screening, no mechanical deep testing was conducted at this location.

5.2.4.2.14 Deep Test Location 8: Section 21, Township 81, Range 24

Deep test location 8 comprised an area within or immediately adjacent to previously recorded sites HaRk-46, HaRk-16, and HaRk-23. Investigations at each site are summarized individually below.

5.2.4.2.14.1 HaRk-46

Stage one pre-screening consisted of three combination shovel and auger tests, judgementally excavated within and adjacent to HaRk-46. The tests were excavated by shovel to depths of approximately 100 centimetres, then extended by bucket auger to 195 to 430 centimetres below surface. The depths of deposit encountered in the auger tests and the presence of archaeological materials in nearby subsurface test 45,828 between 64 and

68 centimetres below surface, indicated that further testing was warranted. To that end, two trenches (trenches 1 and 2), measuring approximately 2.4 to 2.6 metres by 0.9 metres were excavated in sand dune features (stage two).

Observed stratigraphy was generally similar in both trenches, with many thin layers of variably brown silt ranging in thickness from approximately 1 to 10 centimetres, with occasional slightly thicker layers ranging up to approximately 15 centimetres. Below approximately 60 centimetres in depth, thicker layers (20 to 40 centimetres) of silt or silty-sand were observed. A thick layer of medium-brown sand was observed at the bottom of both trenches, commencing at 150 centimetres below surface in trench 1 and at 164 centimetres in trench 2. Both layers extended to the maximum extent of excavation at 225 and 215 centimetres below surface, respectively.

One piece of quartzite shatter was recovered from trench 1 at approximately 48 centimetres below surface. Another piece of quartzite debitage was recovered from between 50 and 75 centimetres below surface. Two calcined mammal bone fragments were recovered from trench 2, between 75 and 100 centimetres below surface.

5.2.4.2.14.2 HaRk-16

Two trenches were judgementally excavated within HaRk-16 to locate deeply buried archaeological materials. The trenches measured 2.3 to 2.4 metres by 0.9 metres and ranged in depth from 1.9 to 2.3 metres.

The stratigraphic profile observed in trench 1 consisted of several layers of medium-brown sandy-silt (n = 4) ranging in thickness from 2 to 52 centimetres with several (n = 4) very thin layers of black silt measuring approximately 1 centimetre in thickness interbedded between the sandy silt layers. The black silt layers are found at the following depths below surface: 1) 25 to 26; 2) 30 to 31; 3) 55 to 56; and 4) 113 to 114. Medium-brown sand with trace silt was observed, extending from 114 centimetres below surface to the extent of the excavation at 230 centimetres. Three charcoal samples were collected from trench 1 at approximately 21 centimetres, 55 centimetres, and 105 centimetres below surface. Radiometric dating of charcoal obtained from 55 centimetres below surface produced a result of 1,840 ± 30 BP. Another charcoal sample from 105 centimetres below surface produced a date of 2,420 ± 30 BP (see Section 5.2.5.3).

The stratigraphic profile observed in trench 2 is similar to that observed in trench 1. Several (n = 7) thin layers (<1 centimetres) described as “dark brown organic” or “medium-brown organic” are found interbedded between thicker layers of sediment described variably as medium-brown silt with a trace of clay to orange clay with a trace of silt. These layers range in thickness from 1 to 19 centimetres. The organic layers are found at the following depths: 1) 23 centimetres; 2) 38 to 39 centimetres; 3) 55 to 56 centimetres; 4) 60 to 61 centimetres; 5) 67 centimetres; and 6) 84 centimetres below surface. Medium-brown, silty sand or sand with a trace of silt or with orange silty clay lenses were observed below the lowest organic layer (84 centimetres below surface), to the extent of the excavation at 190 centimetres below surface. One charcoal sample was collected from the west wall of trench 2 from a dark brown organic layer at approximately 24 centimetres below surface. A fragment of large mammal long bone was collected between 125 and 150 centimetres below surface, near the bottom of the trench. Radiometric dating of this sample produced a date of 2,870 ± 30 BP (see Section 5.2.5.3).

Based on the radiocarbon dates obtained from the charcoal and bone samples, HaRk-16 is considered to be a multi-component site that has potentially been occupied at least three times over a thousand year period, between 1,840 BP and 2,870 BP .

5.2.4.2.14.3 HaRk-23

Two trenches were excavated within archaeological site HaRk-23 to locate deeply buried archaeological materials. The trenches measured 2.4 metres and 2.6 metres by 0.9 metres, and were excavated to depths of 2.25 to 2.3 metres below surface.

The profile in trench 1 consisted of several layers (*n* = 13) of silt, sand, or sandy silt in varying colours ranging from dark brown to orange. The layers ranged in thickness from 1 to 13 centimetres in thickness and extended from the surface to 87 centimetres below surface. Charcoal was observed in two layers, at 18 to 29 centimetres and 51 to 52 centimetres below surface. Similarly, orange sandy silt with dark staining was observed between 61 and 71 centimetres below surface. From 87 centimetres to the maximum extent of excavation at 225 centimetres below surface, a homogenous layer of medium brown sand was observed. One piece of chert debitage was collected between 25 and 50 centimetres below surface. Further, a sample of wood was collected from a layer of dark brown sandy silt between approximately 34 and 44 centimetres and a charcoal sample was collected from a layer of medium brown sandy silt at approximately 45 centimetres below surface. Radiometric dating of the charcoal sample produced a result of 1,250 ± 30 BP (see Section 5.2.5.3).

The excavation of trench 2 revealed a stratigraphic profile similar to that of trench 1. Many layers (*n* = 16) of sediments, variable in content and colour, were observed between 0 and 145 centimetres below surface. The layers range in thickness from 1 to 23 centimetres and in colour from medium-brown to orange. The sediment varies from silt to sand, silty sand, or sandy silt. Charcoal was observed in one layer of orange silt extending from 65 to 71 centimetres below surface. From 145 centimetres to the extent of excavation at 230 centimetres below surface, sediments consisted of 45 centimetres of medium-brown, silty-sand overlying 40 centimetres of medium-brown sand. Archaeological materials, in the form of obsidian and chert unifacially retouched flakes, chert debitage, and faunal materials (which include a freshwater mollusc shell), as well as burnt and calcined mammal and bird bone fragments were observed between 100 and 160 centimetres below surface. Radiometric dating of calcined bone from 125 to 160 centimetres below surface produced a date of 2,200 ± 30 BP. Calcined bone from 100 to 125 centimetres below surface produced a slightly older date of 2,280 ± 30 BP (see Section 5.2.5.3).

The results of the radiometric dating suggest that HaRk-23 is a multi-component site that was occupied at least twice over a thousand-year period between 2,280 and 1,250 BP.

5.2.4.2.15 Deep Test Location 9: Section 15, Township 82, Range 25

At deep test location 9, three trenches were excavated approximately equidistantly along the toe of an alluvial fan, at the edge of the reservoir. All of the trenches were placed within a field presently used as pasture. The sediments observed in each trench comprised variations of compact medium and light brown silt with some sand, mixed with gravel inclusions. Trenches 1 and 2 are similar in that they contained gravels only in the upper

80 to 85 centimetres of sediments, while trench 3 showed some layers containing gravel to the maximum limit of excavation at two metres below surface. Within trench 2, a layer of intermittently mottled dark brown sediment was observed at 80 to 85 centimetres below surface. No evidence of buried soil horizons or archaeological features was observed, and no archaeological materials were recovered. The stratigraphic variations observed within the three trenches are consistent with what would be expected in an alluvial fan deposit.

5.2.4.2.16 Proposed Deep Test Location 10: Section 28, Township 83, Range 20

5.2.4.2.16.1 HbRg-61

At deep test location 10, stage one pre-screening consisted of six auger tests placed at the southern end of an alluvial fan, on the lower terrace overlooking the Peace River near archaeological site HbRg-61. Auger tests were excavated to the effective reach of the tool, between 200 and 400 centimetres. One of the auger tests was excavated through a positive adaptive test within HbRg-61; the remaining auger tests were located within negative judgemental tests in the general vicinity of HbRg-61 at the southern end of the fan. Sediments that were encountered included stratified layers of silts, silty clays and sands, with no stony inclusions. While variations were observed from test to test, the upper sediments generally consisted of medium-brownish to grey silts to approximately 120 centimetres below surface, underlain by dark grey clay to approximately 180 centimetres, followed by alternating bands of medium brown and dark grey silts extending to the bottom of the tests.

Sediments at the southern end of the fan appeared to be moderately-to-well sorted, and stratified, with the fan itself having a relatively shallow slope. No artifacts were encountered during the auger testing, but the tests indicated the potential for deep cultural deposits.

5.2.4.2.17 Wetlands

As described in Section 5.1.5.10.1, the archaeological program intended to explore the possibility that perishable artifacts and other cultural materials might be present in LAA wetlands, as found in other riparian environments in the Pacific Northwest (e.g., Nicholas 1998; Stevenson 1998). The methods proposed for such locations were intended to mix the judgmental and deep-testing strategies discussed previously, with the intent of using a backhoe or excavator to test wetland margins and see if perishable artifacts (in this region, potentially including objects made of hide and sinew, as well as wooden implements) could be recovered. Judgmental testing was also proposed in the terrestrial peripheries to wetlands, with an expectation that these would have been high-productivity settings for several traditional resources, including game animals.

Few wetlands were encountered during the 2011 and 2012 field programs, and none were backhoe tested. Although access issues did not permit backhoe testing at any wetland setting, it was possible to shovel test such deposits. This testing was completed in targeted locations at Watson Slough and Boucher Lake, the only two LAA wetlands adjacent to archaeological sites with high artifact frequencies (Figure 5.18). Shovel testing on dry lands adjacent to wetlands was completed in both 2011 and 2012 coincidentally with the systematic grid testing, as well as with judgemental tests at the margins of these wetlands.

Judgemental testing was completed at Watson Slough in wet deposits adjacent to: sites HbRh-136 and HbRh-137, located on colluvial fans on the north side of Watson Slough; at HbRh-66 located along the south margin of the slough; HbRh-126 and HbRh-135, located on elevated landforms within the eastern portion of the slough; and HbRh-38, which is located in the currently inundated northeast portion of the slough. None of these tests were positive for archaeological remains. It should be noted that beaver dams and Clemson levelers installed by Ducks Unlimited for habitat improvement are present at the downstream (northeast) end of Watson Slough, causing water levels in the slough to be artificially high.

Judgemental shovel testing was also completed in wet terrain immediately west of site GlRj-2, located southeast of Boucher Lake. Lands immediately south of Boucher Lake are open and grassy with scattered stands of willow, and are likely flooded periodically by rising water levels in the lake. The judgemental subsurface tests revealed a thick organic layer at the surface overlying generally fine-textured sediments (silt and clay), indicative of periodic inundation. One of these judgemental tests contained a very small chert flake. No organic archaeological remains were identified.

5.2.4.2.18 Small Landforms

Section 5.1.10.2 provides the rationale for the small landform survey strategy that was principally implemented in 2011. LiDAR mapping used for the GIS model identified 306 localized (≤100 m²) landscape features elevated above surrounding terrain otherwise modeled as having moderate or low archaeological potential. A cluster of eight systematic tests was programmed on each small landform, for a theoretical total of 2,269 tests.

As specified in (amended) B.C. *Heritage Conservation Act* Permit 2010-0378, a sample of small landforms was selected for inspection during the 2011 field program. However, upon inspection by the crews, all of the survey locations proved to be either undifferentiated from the surrounding terrain, had been misidentified as landscape features (e.g., uprooted trees), or were in obviously low potential settings (e.g., active floodplains). A total of 169 negative tests were excavated at these locations during the field survey. It was concluded that the “small landforms” detected by LiDAR did not signify the existence of genuine terrain features that correlate with archaeological site locations.

5.2.4.2.19 Traditional Land Use Sites

Investigation of potential archaeological remains associated with sites or places of cultural significance was proposed as one of the 2011 program objectives. As no information about such locations was forthcoming prior to the onset of the 2011 or 2012 field programs, no targeted investigations of traditional use sites were conducted. Post-field examination of traditional land use studies made available for the Project indicates a number of traditional use areas were coincidentally investigated during the field program.

5.2.4.2.20 Investigations Adjacent to Rocky Mountain Fort

As detailed in Section 5.1.10.4, among the objectives of the field program was an exploration of the possibility that contemporary Aboriginal encampments were associated with the historic fur-trading post at Rocky Mountain Fort (HbRf-31). For this purpose, a judgmental subsurface testing strategy was adopted, based on a test interval of 10 metres. Crew Leads selected locations peripheral to the known boundary of the fort, including suitable camping sites upstream and downstream, and across the Peace River from the site, based on historical records of comparable encampments in this region (e.g., Burley, et al. 1996).

Subsurface testing focused on the Peace River north bank directly across from the fort, as well as lands upriver and downriver from the fort on the south bank (Figure 5.19). A total of 893 subsurface tests were excavated during the field survey. None were positive for cultural materials.

5.2.4.3 Archaeological Site Inventory

A total of 251 Pre-contact archaeological sites were identified and recorded within the LAA, during the 2010 to 2012 field seasons for the Project. Summary descriptions of these archaeological sites will be found in Appendix F of this report. In addition to these sites, there are 12 documented sites recorded from settings that are in close proximity to various Project components and areas – principally the reservoir. The records from these sites were examined to determine that these sites are clearly outside the LAA and their known boundaries did not overlap with any Project components. These sites, identified below in Table 5.18, are not included in this heritage assessment.

Table 5.18: Archaeological sites adjacent to and outside the LAA

Site	Locational Analysis
HaRj-6	■ Site record identifies site as being “5 m” back from edge of terrace ■ No testing done by Golder team in immediate area ■ Reservoir is below terrace edge where site is located ■ Site is located beyond reservoir
HaRk-7	■ Site is outside reservoir
HaRk-8	■ Site is outside reservoir
HaRk-19	■ Site record gives site dimensions as 40 m x 20 m, but digitized site area is only 1 m x 1 m ■ Site record describes site as lithic scatter on a cattle trail ■ Nearest Golder team tests are at newly recorded site HaRk-53, 55 m to the SW ■ Site is located beyond reservoir
HaRk-29	■ Historical site – Beatty Homestead ■ Not a Pre-contact site
HbRf-41	■ Site is located at the point of a high terrace overlooking confluence of Peace and Moberly rivers ■ Subsurface testing conducted by Golder team to the NE on a lower terrace ■ Reservoir is down-slope from the site ■ Site is located beyond reservoir

Site	Locational Analysis
HbRg-4	■ Digitized site polygon in RAAD measures 1 m x 1 m but site record gives much larger size ■ No testing done by Golder team in immediate area ■ Reservoir is below terrace edge where site is located ■ May be part of site HbRg-15 ■ Site is located beyond reservoir
HbRg-16	■ Digitized site boundary plots the very northern tip of the 50 m diameter site buffer as within the Reservoir ■ SFU 1976 field notes state that the site is “15-20 m from terrace edge” ■ Testing conducted by Golder team north of site on lower river terrace ■ Reservoir is just below terrace edge, to north ■ Site is located close to HbRg-23 and HbRg-38 ■ Buffered site boundary is within reservoir, but the location of the artifact finds is beyond the reservoir
HbRg-19	■ Millennia Research re-plotted site location in 2010 ■ No testing done by Golder team in immediate area ■ Reservoir is below eastern landform edge, where Wilder Creek is located ■ Site is located beyond reservoir
HbRg-22	■ Located on intermediate terrace overlooking Peace River ■ No testing in vicinity of site by Golder team ■ Reservoir is north of site just below terrace edge on which site is located ■ Site is located beyond reservoir
HbRg-23	■ No testing in vicinity of site by Golder team ■ Reservoir is north of site just below terrace edge on which site is located ■ Site is located beyond reservoir
HbRg-38	■ Surface find on existing trail ■ No subsurface testing done ■ Located on same terrace as HbRg-23 ■ Testing conducted by Golder team north of site on lower river terrace ■ Reservoir is north of site, just below terrace edge upon which site is located ■ Site is located beyond reservoir
HbRg-43	■ Found by Golder team in 2010 ■ Surface find – no subsurface tests in vicinity by Golder team ■ Site is located beyond reservoir

5.2.5 Analytical Results

The following sections present the results of the analyses of lithic artifacts, faunal remains, radiocarbon dating, and erosion potential.

5.2.5.1 Artifact Analysis

A total of 15,113 artifacts were recovered from 184 archaeological sites that were recorded or revisited in the LAA over the course of three field seasons. The majority of recovered artifacts consist of objects made, used, and discarded by Aboriginal peoples prior to European contact. All recovered Pre-contact artifacts are made of stone of various types with an overwhelming reliance on locally available lithic materials.

The artifact assemblage is primarily composed of stone tool manufacturing by-products, commonly referred to as debitage. The remainder of the assemblage (*n* = 533; 3.5%) is made up of 528 formed and expedient flake tools, most of which are retouched or utilized flakes, four hammerstones, and one sandstone abrader that represents the only evidence for groundstone technology recovered over the course of 2010 to 2012 field investigations in the LAA.

The following is a summary of the artifact analysis, with a particular focus on formed tools such as projectile points, bifacial and unifacial tools, cores, and other chipped stone implements. Definitions for each artifact class are provided in Appendix A, and site-specific artifact tables are presented in Appendix F of this report.

5.2.5.1.1 Debitage

Unmodified debitage, the by-product of stone tool manufacture and maintenance, is the most abundant artifact category in the overall lithic assemblage from the LAA (*n* = 14,577; 96.4%). Unmodified flakes were categorized according to the presence or absence of a striking platform, the point where the initial force used to detach the flake was focused. For platform remnant-bearing flakes, the number of previous flake scars on the platform was used as the primary means of distinguishing between reduction stages (Magne 1985). Flakes without a recognizable platform and non-flake debitage, together referred to as “shatter,” were sorted according to reduction stage using dorsal scar count. Bipolar and bifacial reduction flakes were also identified, and were catalogued in the same manner as for platform remnant-bearing flakes and shatter.

The majority of the debitage is shatter, comprising 69% (*n* = 9,999) of the entire debitage assemblage (Figure 5.20). Platform remnant-bearing flakes are the next most common (28%, *n* = 4,023) while bipolar and bifacial reduction flakes make up the smallest portion of the assemblage.

The three main stages of lithic reduction (primary, secondary and tertiary) are represented almost equally in the overall debitage assemblage from the LAA. Tertiary or late stage reduction flakes slightly more common (34%), followed by secondary (33.5%) and primary (32.5%) (Figure 5.21). Among platform remnant-bearing flakes, primary reduction flakes are slightly more common (38%), followed by secondary (32%) and tertiary (30%) (Figure 5.22). At a gross level, this distribution suggests that all stages of lithic reduction took place at various sites within the LAA.

In addition to recording flake types and scar counts, the debitage was measured and assigned to a size classes (Figure 5.23). Debitage ranging from 0.1 to 3 mm in maximum dimension (size classes 1 to 3) are the most common size classes, comprising approximately 91% of the entire debitage assemblage. As debitage size is often related to core size (Andrefsky 2005), it is not unexpected that small waste flakes are the predominant size class in the assemblage given that the majority of suitable tool stone present in the LAA occurs as small to medium sized river cobbles.

5.2.5.1.2 Tools

The overall assemblage from the LAA included 533 formed and expedient tools. Table 5.19 summarizes the frequency and relative frequency of the tool types, and the following sections describe the stone tool assemblage.

Table 5.19: Frequency and relative frequency of tool types

Tool Type	Frequency	Relative Frequency
Projectile Points		
Small side-notched points	2	0.38
Medium corner-notched points	4	0.75
Lanceolate points	1	0.19
Projectile point tip	1	0.19
Projectile point base	2	0.38
Lanceolate point base	2	0.38
Basally thinned projectile point base	2	0.38
Microblade fragments	10	1.88
Microblade cores	2	0.38
Macroblades	14	2.63
Bifacial retouch tools		
Complete	11	2.06
Fragments	43	8.07
Large Bifaces		
Complete	5	0.94
Fragments	8	1.50
Graver/Drill	2	0.38
Core tools	114	21.39
Pièces Esquillées	4	0.75
Abrader	1	0.19
Spall tools	6	1.13
Endscrapers	17	3.19

Tool Type	Frequency	Relative Frequency
Unifacial retouch tools		
Complete	48	9.01
Fragments	94	17.64
Utilized flakes	136	25.52
Hammerstones	4	0.75
Total	**533**	**100.00**

5.2.5.1.2.1 Projectile Points and Point Fragments

Fourteen projectile points or fragments of projectile points were recovered from 13 different sites throughout the LAA (Appendix N-2, Photograph 15: a-i and Photograph 16: a-d). Three are complete specimens (Appendix N-2, Photograph 15: c, f, and g) and four others are mostly complete (Appendix N-2, Photograph 15: a,b, h,i), either missing the tip or a small portion of the base.

One of the complete points (Appendix N-2, Photograph 15: g) has excurvate margins, corner-notches, and a concave base, and resembles a Hanna point from the McKean complex in the Northern Plains cultural sequence (Kooyman 2000; Peck 2011). Only one face of this artifact exhibits flaking that extends right to the mid-point of the blade, while the opposite face exhibits only minor retouch to the lateral margins. On the Northern Plains, Hanna points are dated to the Middle Prehistoric period, roughly 4,100 to 3,100 years BP (Kooyman 2000; Peck 2011). A projectile point similar in style to both of these points was found at Charlie Lake Cave and dated to between 4,200 and 2,900 years BP (Fladmark 1996).

A second nearly complete point (Appendix N-2, Photograph 15: i) also resembles a Hanna point, with slightly less excurvate margins. One of the lateral margins has been broken off in a burinated fashion, likely a result of an impact that broke the tip, removing any signs of retouch or other preparation of the point blade.

The third complete projectile point (Appendix N-2, Photograph 15: f) was recovered from GlRj-2 within the transmission line corridor. This specimen is a lanceolate point made from medium-grained black banded chert, with slightly excurvate margins and a concave base. Flake scar patterns on either face are irregular with some evidence for re-sharpening and possibly edge grinding. The basal margin has been thinned via the removal of flakes from either face and exhibits evidence of damage from hafting in the form of overlapping groups of step-terminated flake scars. A small portion of one of the basal corners was broken off prior to recovery, but the corner fragment was present in the same shovel test and was refitted to the artifact. In addition, a small portion of the tip of this point has been broken in a transverse fashion, possibly due to impact. This projectile point style cannot be attributed to a specific time period based on its morphology.

A mostly complete point was found in the Watson Slough locality at site HbRh-145 (Appendix N-2, Photograph 15: a). It is made of black chert with a few bands of white quartz and is broken transversely at the distal end, damage that resulted in the removal of roughly one-third of the blade portion. The base is corner-notched with sharp tangs and a somewhat long, thin stem and square basal margin, and the lateral blade margins are slightly excurvate. This projectile point most closely resembles the Pelican Lake or Bracken point styles from the Northern Plains, which date between 3,600 and 2,100 years BP (Peck 2011). Two of the five projectile point bases identified in the artifact assemblage bear some resemblance to this point style. However, not enough of the entire points remain to make a more definitive classification about their finished appearance.

Also present in the projectile point assemblage are two small side-notched points. Both of these points are either complete or mostly complete, and one is missing only a small portion of the basal margin (Appendix N-2, Photograph 15: b and c). This point style is typical of the latest part of the Late Prehistoric period, dating between approximately 1,200 years before present and the Contact era, and likely reflects the introduction and proliferation of bow and arrow technology (Carlson and Magne 2008; Peck 2011).

Other point styles discernible among the artifact assemblage are represented by the basal portions of four additional fragmentary projectile points (Appendix N-2, Photograph 16: a-d). The first specimen (Appendix N-2, Photograph 16: a) is made from banded black chert with expanding margins, a relatively thin cross-section, and a basally-thinned, concave base. The basal thinning appears to have been effected by the removal of two flakes from both faces in a fashion similar to, but not precisely the same as Clovis and other broad concave-based lanceolate Palaeo-Indian projectile points (Vickers 1986; Carlson and Magne 2008; Peck 2011). Based on the evidence of basal thinning through removal of a single channel flake, this point may date to the latter portion of the Early Period, or possibly to the early part of the Middle Period (ca. 7,500 to 6,000 years BP).

One other point base in the assemblage also bears evidence of basal thinning, to a lesser degree than the example noted above (Appendix N-2, Photograph 16: b). This specimen is made from fine-grained black chert and has expanding margins, a relatively thick cross-section, and a concave base with several small thinning flakes removed from the basal margin. While one or two of the basal thinning flakes appear to have been removed via soft hammer percussion, the majority are small enough that they likely represent final shaping of the point by pressure flaking.

The artifact shown in Appendix N-2, Photograph 16: d represents a stem of what was possibly a much larger projectile point. It is finely made, thin in cross-section with a slightly concave base and what may be a small lateral tang at one corner of the basal margin. Edge grinding is apparent along the lateral margins. It has slightly expanding margins and has been broken transversely.

The last recognizable point style is represented by the basal portion of what appears to have been a small, leaf-shaped point made from fine-grained black chert (Appendix N-2, Photograph 16: c). The point is relatively thin in cross-section, and has slightly expanding, excurvate margins and a square base. This point style is not particularly diagnostic with respect to documented temporal periods of the Northern Plains (e.g., Peck 2011), but assuming this projectile point was used to arm an atlatl dart, it seems plausible that it predates the introduction of the bow and arrow roughly 1,200 years ago (Carlson and Magne 2008; Peck 2011).

The remaining artifacts in the projectile point assemblage are all broken tips, which cannot be referred to any specific style, but are nonetheless distinguishable as being part of a projectile point.

5.2.5.1.2.2 Microblades and fragments

Microblades and microblade cores have been previously found in the Peace River valley (Spurling 1980b), but tend to be more common in plateau settings such as Charlie Lake (Fladmark 1996; Archer 2009a). While the temporal attribution of microblade-bearing sites in this region is uncertain, most are believed to range in age from the Early to Middle Prehistoric periods (10,700 to 4,500 BP) providing at least tentative temporal context for archaeological sites where they occur. Dated microblade-bearing sites include Charlie Lake Cave (Driver, et al. 1996) and HbRh-66 (Spurling 1980b). Excavations at Charlie Lake Cave produced a microblade core in association with a raven skeleton from Component 3, dated to approximately 9,500 BP (Driver, et al. 1996).

Ten microblades were recovered from four sites in the LAA, two of them (HbRf-93 and HbRh-122) within the Peace River valley and two (HaRf-32 and HaRj-32) on the plateau within the transmission line corridor. While several microblade fragments were found at both of the plateau sites, only single proximal fragments were identified at the two valley sites.

The microblade fragments from the two sites in the Peace River valley (Appendix N-2, Photograph 17: a and b) are both proximal portions with intact platforms, and exhibit fluted flake scars as evidence of previous blade removals. The microblade fragment from HbRf-93, located on the south bank of the Peace River, is made of fine-grained black chert and exhibits clear signs of platform preparation, with blades having been removed using either soft hammer percussion (i.e., an antler billet) or the punch technique (Sollberger and Patterson 1976; Crabtree 1982). There is no use-wear on either remaining margin of this artifact. The other microblade fragment is from site HbRh-122 in the Watson Slough locality and is made from a coarse-grained, weathered grey chert.

The first of the two plateau microblade sites, HaRf-32, contained two microblade fragments (Appendix N-2, Photograph 18: c-d). The microblades are struck from two different chert varieties, respectively brown and tan in colour, with evidence for multiple previous blade removals apparent in the dorsal flake scars. The brown chert microblade is a distal portion with five dorsal scars and possible evidence of utilization in the form of a bright, glossy polish on the ventral surface. The other blade fragment is a medial portion with three dorsal scars and does not show any signs of utilization.

A concentration of microblades was identified at the second plateau site, HaRj-32, where six chert blade fragments (four proximal, one distal, and one medial) were recovered from six subsurface tests (Appendix N-2, Photograph 18: a-b, e-h). The microblades from this site are made from five different types of chert and none appear to have been struck from a microblade core recovered from the site. The distal microblade fragment ends in a pointed feather termination, and there is evidence of crushing resulting from the blade removal process where the core was likely resting upon an anvil, causing slight damage to the distal margin.

5.2.5.1.2.3 Microblade cores

Two small, wedge-shaped microblade cores were recovered from two sites within the transmission line corridor, both of them in association with microblades. The core identified at site HaRj-32 (Appendix N-2, Photograph 19) is made from a mottled tan chert and bears evidence of previous tablet removals intended to rejuvenate the striking platform. At least seven blade scars are apparent on the fluted face of the core and with a current flute length (i.e., the potential length of blade) of 14.5 mm, it is not likely that any further blades could be removed from this core and still be useful cutting implements. This core therefore is considered to be exhausted.

The second core was recovered from site HaRf-32 and is made from Anahim obsidian (see Section 5.2.1.4.2 and Appendix G). Only two blade scars, or facets, are present on the fluted face of this core, which measures 40.2 mm in length. Also present on the fluted face is a small (approximately 11 mm) hinge-terminated flake scar extending from the platform and likely representing a failed blade removal. At the lip of the platform on the fluted face are numerous small flake scars from either platform preparation or utilization. A large flake has been removed from this core perpendicular to the fluted face of the core, which would have rendered further blade removal impossible.

5.2.5.1.2.4 Macroblades and fragments

While a macroblade industry has not previously been documented for the LAA, it is reported from sites in the drawdown areas of the Williston Reservoir of the Rocky Mountain Trench (Millennia 2008), northwestern British Columbia (Fladmark 1985a), and northwestern Alberta (LeBlanc and Wright 1990). In addition, macroblades have been identified at more distant archaeological sites in the southern Interior Plateau of British Columbia (Stryd and Rousseau 1996). Macroblade technology has been asserted to have strong links to Clovis culture, with several Clovis sites producing evidence of well-developed macroblade industry (e.g., Collins 1999; Dickens 2005).

Macroblades were recovered from two sites in the Peace River valley (HbRi-43 and HaRj-27). Both of these sites are on the north side of the Peace River, on the first series of intermediate terraces above the river. At HaRj-27, a single, prismatic distal blade fragment made of black chert was found (Appendix N-2, Photograph 20). This artifact bears evidence of at least four previous blade removals and is missing the platform or proximal portion. The distal margin has been steeply retouched into what appears to be an endscraper, while both lateral margins of the blade show signs of heavy use-wear. The blade termination is characteristic of an overshot or *outrepassé* flake. Flakes of this sort are created when the force applied to remove the blade or flake is excessive enough to cause a portion of the opposite margin of the core to be removed (Andrefsky 2005). This type of controlled flake removal is very specialized and is considered characteristic of Clovis assemblages (Haynes 2002).

In addition, an obsidian macroblade assemblage was recovered from HbRi-43 (n = 13; Appendix N-2, Photograph 21). The obsidian used to manufacture these artifacts is derived from two source locations: Anahim Peak in the Chilcotin and Mt. Edziza in northwestern British Columbia. While all specimens are fragmentary, several can be retrofitted with other fragments in the assemblage. Morphologically, these blades are not similar to the one recovered at HaRj-27, being much narrower in width and cross-section and being clearly not overshot flakes.

5.2.5.1.2.5 Bifacial tools and fragments

Bifacial tools, whether complete or fragmentary, are one of the more common tool types recovered and comprise approximately 12.5% of the formed tool assemblage (*n* = 67). Within this artifact category are distinctive tool subtypes such as large, ovate, and lanceolate bifaces. The bifaces shown in Appendix N-2, Photographs 22 and 23 are all of the ovate variety and likely would have served several purposes, such as cores from which flakes were struck to produce other tools, or used without further modification as cutting or scraping implements. The bifaces shown in Appendix N-2, Photographs 24, 25, 26 and 27 are much larger than the ovate forms. While the original forms of the bifaces in Appendix N-2, Photograph 24 are not discernible in their present state, it appears at least that they may have been similar in shape and design to the complete, large bifaces in the assemblage, shown in Appendix N-2, Photographs 25, 26 and 27.

In terms of function, the large bifaces likely served similar purposes as the ovate bifaces described above, both as cores and as functional tools themselves. The possibility that these artifacts were used as cutting, chopping, or scraping tools is suggested by fine retouch along the margins, which would have taken place at the final stage of tool manufacture and shaping. Several of these artifacts show an interesting breakage pattern. All of the

bifaces shown in Appendix N-2, Photograph 24 are broken transversely, a type of break common to projectile points in a high-velocity impact against a hard object, such as bone, a tree, or a rock. The pattern evident here would suggest that perhaps these artifacts were used for some other, but common, purpose, as heavy choppers for example.

Four complete, large bifaces were recovered from archaeological sites in the Peace River valley (HaRk-12, HaRk-52, HbRh-54, and HbRh-130; Appendix N-2, Photograph 25 [a and b], Photograph 26, and Photograph 27). These artifacts are generally leaf-shaped and, with the exception of the biface from HbRh-54, bear signs of having once being hafted. The proximal end of the artifact from HaRk-12 contracts into a stem and the biface from HaRk-52 has been notched. While it is unlikely that these bifaces were used as armatures on projectiles, they may have served as hafted cutting or scraping implements.

A single lanceolate biface fragment was recovered from HbRg-5 (Appendix N-2, Photograph 28), on the north bank of the Peace River east of Bear Flat. This artifact is made from fine-grained grey chert, and both the distal and proximal portions have been broken off. Recovered from the same subsurface test with this artifact were several worked fragments of the same material that were later recognized as being parts of this biface. All but two of the small fragments have been refitted to the original piece that appears to have been shattered due to an impact, as suggested by transverse breaks to the proximal and distal ends. It is possible that this artifact may have been further damaged *in situ*, due perhaps to post-depositional actions such as ploughing or frost heaving, thus causing the small fragments to become detached. The fine flaking on both faces of this artifact, along with the presence of edge grinding, is suggestive of earlier point styles and may possibly date this item to the Early Prehistoric period (ca.10,000 to 7,500 BP).

Also present in the bifacial tool assemblage are five biface preforms (Appendix N-2, Photograph 29). A preform is an artifact at a secondary or tertiary stage of manufacture, prior to reaching its finished form, but often with the finished form readily identifiable (Andrefsky 2005), as is the case with two of the artifacts shown in Appendix N-2, Photograph 29 a and d. These two preforms are triangular with relatively squared bases, and appear to have been discarded prior to completion, possibly due to perceived imperfections in the raw material. The remaining preforms (Appendix N-2, Photograph 28 b, c, e) are more oval in outline and have thin cross-sections and a considerable density of flake scars across both faces. While the final form of these artifacts is not distinguishable in their present state, it is suspected that the intention was to further reduce the preform into a formed tool or projectile point. The last of the five preforms is roughly triangular, but is at an earlier stage of production than the other artifacts in this class.

Two other bifacial artifacts bear mention as they are unique in the formed tool assemblage. The first was recovered from HbRh-57 and is the medial section of a small, finely made, narrow implement of unknown function (Appendix N-2, Photograph 30, b). The artifact is roughly diamond shaped in cross-section and has parallel to slightly excurvate margins. The flaking on both faces exhibits both collateral (i.e., perpendicular to the longitudinal axis) and oblique (i.e., roughly diagonal to the longitudinal axis) flaking. There is possible evidence of utilization along one margin in the form of a series of step-terminated flake scars that do not appear to have been the result of intentional retouch. The function of this artifact is not apparent in its present fragmentary state.

The other unusual artifact in this group is a small, narrow, bifacially retouched flake that may be a retouched microblade or backed bladelet (Appendix N-2, Photograph 30, a). Made from mottled grey chert, this artifact is a proximal portion of either a blade-like flake or microblade that has been bifacially retouched along a single margin. The opposite margin is not retouched, but a slight amount of use-wear is apparent on the ventral surface.

5.2.5.1.2.6 Cores and core tools

Cores and core tools form the third largest artifact category in the tool assemblage, comprising approximately 21.2% of all tools recovered (*n* = 114). Cores and core tools are distinguished by their role, either as a source of flakes for further reduction, or direct use for other activities, such as rough chopping or cutting. While all cores are catalogued for the present study as core tools, each artifact may or may not have been used as a tool as defined above. There are four primary core types in the assemblage: unidirectional, multidirectional, bipolar, and bifacial (Appendix N-2, Photographs 31, 32, 33, 34 and 35). The core assemblage is varied in terms of reduction stage or level of exhaustion (e.g., Appendix N-2, Photograph 36), with some cores having only a few flake scars while others exhibit multiple flake scars and attempts at rejuvenation. Bipolar cores are perhaps the most common type in the assemblage of cores and core tools. The method of reducing or creating a bipolar core is done by placing a pebble or cobble on an anvil stone and striking straight down on the stone. This reduction method is difficult to control and usually results in the splitting or shattering of the core (Whittaker 2005). Given the nature of lithic raw materials in the LAA, where cobbles and pebbles predominate, it is not surprising that bipolar cores and associated waste flakes are common.

An unusual artifact at HaRj-23 has been tentatively classed as a core tool (Appendix N-2, Photograph 32). It is made from a medium-sized cobble of relatively coarse-grained igneous rock approximately 11.5 cm long and 7.1 cm wide. The object has been unifacially flaked around the lateral margin but still bears smooth cortex on both unworked faces. The coarse-grained nature of the raw material would not appear to produce good quality flakes for further reduction or for use in an unmodified state.

One of the byproducts or remnants of bipolar core reduction is *pièces esquillées,* also known as stone wedges. These artifacts are usually square or rectangular in outline, exhibit significant battering to two or more margins, and have numerous flake scars on both faces. While these artifacts are known to be the result of bipolar core reduction, it is unclear whether they had other functions in the lithic toolkit of ancient peoples. Four *pièces esquillées* were identified in the Site C artifact assemblage, from four different sites. The *pièce esquillée* from HbRi-61 is a good example of this core type (Appendix N-2, Photograph 34). It is made from black chert and exhibits the characteristic evidence of significant battering on two opposing ends. Cortex is present on one face, and it appears to have been notched on opposing margins, perpendicular to the battered ends. Whether this notching was intentional is unclear.

5.2.5.1.2.7 Abrader

A single sandstone abrader was found in a subsurface test at HbRh-122 in the Watson Slough locality (Appendix N-2, Photograph 37). This artifact is rather unique in the broader context of the Peace River valley, and may have been used to smooth arrow, dart, or spear shafts. The working face has been significantly worn by use into a trough-like groove and is broken on one end. Sandstone is abundant in the Peace River valley and surrounding lands, and thus it is likely that this artifact is made of a locally available material.

5.2.5.1.2.8 Spall tools

Six spall tools and one *chi tho* were recovered from sites in the Peace River valley. Spall tools are easily recognizable as cortical flakes, in this region usually struck from smooth, water-worn quartzite pebbles and cobbles. These tools were made by placing a cobble on an anvil stone and striking the cobble with a blow to the top of the stone. This process results in the removal of a single large flake with a naturally sharp edge and a thicker, blunted proximal portion that prevented injury to the user's hand (Stewart 1981). Early ethnographers in the southern Interior Plateau of British Columbia observed spall tools being used to stretch hides during the tanning process, and they are still used for that purpose in northwestern British Columbia (Albright 1984). Spall tools are common in archaeological contexts throughout British Columbia (Stewart 1981; Hayden, et al. 1996) and on the Northern Plains where they are also referred to as Eldon unifaces (Stewart 2010).

The artifact shown in Appendix N-2, Photograph 38 is an example of a quartzite spall tool. Recovered from HbRg-5, it is a small-to-medium brown quartzite spall tool with slight unifacial flaking to the distal margin and two pronounced notches on both lateral margins. While the notching at the lateral margins is most likely related to hafting, it is uncertain whether the flaking on the distal margin is a result of utilization or intentional retouch.

A single artifact recovered from HbRi-10 is tentatively identified as a *chi tho* (Appendix N-2, Photograph 39). A *chi tho* is a rough, bifacially flaked spall tool or slab scraper– a cutting tool commonly associated with northern Athapaskan assemblages (Morrison 1984; Fladmark 2009). This artifact is made from a large, rectangular quartzite spall with bifacial flaking on all margins and a large amount of cortex still present on the dorsal face. There is evidence of post-depositional damage on the cortical face in the form of metallic residue and scrape-marks, suggestive of a plough impact.

5.2.5.1.2.9 Endscrapers

Endscrapers are a common tool class in North American Pre-contact lithic artifact assemblages. These artifacts are typically steeply retouched, unifacial flake tools that were hafted into composite implements and used for scraping and defleshing hides.

Seventeen complete and fragmentary endscrapers were recovered from several sites throughout the LAA (Appendix N-2, Photograph 40). The majority of these artifacts are made from the ubiquitous black chert, but other materials present in this assemblage include grey and mottled grey chert as well as orthoquartzite. All of these artifacts are very similar in shape and size, as well as in the angle of retouch to the working edge, which ranges between 75° and 90°. All are made on the distal end of robust, slightly curved flakes, some of which bear evidence of further shaping or retouch to the lateral margins. The pattern evident among the broken artifacts suggests stress fracturing due to the heavy loads applied to these tools, thus snapping at the hafting point, leaving behind two fragments.

5.2.5.1.2.10 Unifacial retouch tools and fragments

Unifacially retouched tools represent a diverse artifact category that describes any flake that has been retouched to any degree on only one face. Unifacial artifacts are distinguished here from utilized flakes, which have had their edges modified through use only, rather than intentional retouch. These artifacts are one of the most common tool types found in archaeological sites in British Columbia and, functionally, likely served as everyday, multipurpose cutting and scraping implements. As such, this is the largest artifact class, comprising approximately 26.9% of the entire tool assemblage (*n* = 142) (Appendix N-2, Photograph 41).

Two similarly formed, tabular unifaces were identified at HaRk-15 and HbRi-41 (Appendix N-2, Photograph 42: a-b). Both of these artifacts are sub-rounded in shape with steep-angled retouch to all margins. Each tool is made from a hard hammer flake, based on the robust bulb of percussion on the ventral surface. The dorsal surface of the artifact from HbRi-41 is almost completely flat and totally covered in cortex. A series of step-terminated flake scars on the distal margin indicates that this tool was utilized, likely for hide-scraping as the resemblance of this artifact to endscrapers in the formed tool assemblage is striking, but not similar enough to be classed among them. The artifact from HaRk-15, while complete, appears to have been reworked along part of the distal margin and one lateral margin. Roughly halfway across the distal margin, the retouch switches to the ventral surface and continues along the adjacent lateral margin. This ventral retouch is not as systematic as is apparent on the dorsal surface and may represent use-wear from heavy utilization of this flake tool.

Ten unifacial tools were recovered from sites HbRg-6 and HbRh-122 (four from HbRg-6 and six from HbRh-122). The unifaces from HbRg-6 are shown in Appendix N-2, Photograph 43 and provide a typical indication of the range of variation in this tool class. Based on the edge angles for each of these tools, it is likely they functioned as both cutting and scraping implements, with the more acute-angled tools used for cutting and the steeply retouched artifacts acting as scrapers.

5.2.5.1.3 Discussion

The artifact assemblage recovered from newly identified or revisited sites is diverse, reflecting a multitude of activities and, by extension, site types in the Peace River valley. While only 3.6% of the total assemblage is composed of formed and expedient tools, the artifact assemblage is informative with respect to the temporal span for occupation of the river valley and upland settings, as well as issues of interregional trade and exchange. To this degree, projectile points and microblade and macroblade technologies tend to be most diagnostic of temporal periods, while the presence of exotic lithic materials, such as obsidian, are indicators of broad-scale, interregional trade and interaction.

The projectile points recovered from the field surveys represent a range of styles and associated temporal periods, spanning at least the last 4,500 years, and possibly considerably longer. The majority of the identifiable points in the assemblage were likely dart points used in conjunction with atlatls, a technology associated with the Early and Middle Prehistoric periods. While the basally thinned projectile point fragment from HbRh-36 resembles early point styles, the majority of points likely date to between the latter half of the Middle Period (ca. 6,000 years BP) to the beginning of the Late Period (ca. 4,000 years BP). Two small side-notched points are the only evidence for bow and arrow technology and it is likely that these two points date to the last 1,200 years. The temporal span represented in the projectile point assemblage is consistent with the radiocarbon dating results presented in Section 5.2.5.3, which places occupation and use of some sites in the Peace Valley from around 5,000 years BP to the Contact period.

Beyond the identifiable projectile point styles represented in the assemblage, there are a few specimens reminiscent of earlier styles. In particular, the projectile point base from HbRh-36 had basal thinning flakes removed in a fashion similar to other points from the region that are attributed to Clovis or Goshen traditions, dating to the Early Period (10,500 to 7,500 years BP). Points similar to this have been recovered from the Williston Reservoir (Arcas 2003, 2007; Millennia 2010), Charlie Lake Cave (Fladmark 1981, 1996), Pink Mountain (Wilson 1996), and the Gutah area (Walde 2006). Aside from Charlie Lake Cave, none of these projectile points were recovered from contexts with datable materials. Including the Williston Reservoir artifact finds, all of the sites are located in high terrace or upland settings above adjoining river or stream valleys.

The possibility of Palaeoindian or Early Period occupations in the LAA is further suggested by the occurrence of large blades at two separate locations (HaRj-27 and HbRi-43), both on the north side of the Peace River. As discussed above, it has been proposed that macroblade technology has a strong association with Clovis and Palaeoindian traditions (Collins 1999). Macroblades from northwestern Alberta discussed by LeBlanc and Wright (1990:9-10), while not derived from directly dated contexts, were all found in association with late glacial landforms and are similar in form to Clovis blades elsewhere in North America, and Plano blades from Fisherman Lake in the southwestern Northwest Territories, lending at least partial support to the association of the Peace River blades with early occupations of the valley.

Microblades and associated blade cores have been the subject of much investigation and discussion among archaeologists studying the Pre-contact history of the Subarctic and neighboring regions (e.g., Clarke 1981, 2001; Pyszczyk 1988; Holmes 2001; Magne and Fedje 2007; Younie, et al. 2010). One important aspect of the overall interest in microblade technology in the Subarctic is the timing of the introduction and duration of this unique tool production strategy. The association between early human presence in northern North America and microblade technology is widely accepted and based on secure dates from microblade sites that place the introduction of these implements as early as 11,600 years BP at Swan Point in Alaska (Magne and Fedje 2007). The earliest dated occurrence of microblades in the Peace Region is found at Charlie Lake cave and was recovered from a level dated to 9,500 years BP (Fladmark 1996:11). Another microblade core, similar in form to the one recovered at HaRj-32, was collected from an undated surface context at Fort Vermillion in northwestern Alberta (Magne and Fedje 2007; Pyszczyk 1991).

Problems arise, however, when attempting to assign a terminal date for microblades in northwestern North America (Clarke 1981; Copp 2006; Magne and Fedje 2007). Although a rough estimate of 4,000 years BP is often cited as a terminal date for microblades in the Subarctic, there are a few instances where these artifacts are found in later deposits, such as the Peace Point and Beyza sites in northeastern Alberta that have been dated to 2,200 and 3,900 years BP respectively (Magne and Fedje 2007). The microblade component at Peace Point also extends into the ethnohistoric period (Magne and Fedje 2007). Currently there is insufficient information to confidently assign a terminal date to microblade technology.

5.2.5.1.4 Lithic Raw Materials

The analysis of lithic raw materials, in particular exotic material types such as obsidian for which source information is available, can provide indications of inter-regional trade and interaction (Eerkens, et al. 2008) as well as land use patterns (Brantingham 2006; Andrefsky 2009). Lithic raw materials from sites in the LAA were identified based on macroscopic inspection, with the exception of obsidian, which was submitted for X-ray fluorescence analysis. Some materials that could not be identified were assigned to broader categories of igneous, sedimentary, or metamorphic stones.

5.2.5.1.4.1 Cherts and Other Cryptocrystalline Silicates

The most common lithic material in the study area is black cryptocrystalline silicate or chert, a material common throughout the Peace region. The chert present in the LAA is predominately black to grey-black in colour and grades in texture from cryptocrystalline with a crystalline structure only visible at high magnifications (greater than 200x magnification) to coarse-grained with silica crystals visible to the naked eye. Other varieties of chert present in the assemblage include mottled grey, speckled, and banded cherts, black and white mottled, brown banded, rusty brown, and tan. Other lithic materials in the artifact assemblage include obsidian, quartzite, and orthoquartzite (a clastic metamorphic rock composed almost entirely of quartz sand), granite, gabbro, sandstone, and occasional unidentified lithic materials.

It was noted during the analysis of materials collected from sites along the transmission line corridor that the lithic material types identified at these locations are more diverse than is apparent from archaeological sites in the Peace River valley. For example, two subsurface tests at site HaRj-32 contained artifacts made from several different types or colours of chert, as well as a few pieces of obsidian (Appendix N-2, Photograph 44 and 45). What is perhaps most striking about the lithic raw material types present in the assemblages from the transmission line is the lower frequency of black chert. The ubiquitous black chert is still present, but in smaller quantities and tends to be of a much finer quality than apparent in the assemblages from the Peace River valley. While there are sites in the Peace River valley with a range of raw materials (e.g., HbRh-16), along the transmission line there is conspicuously less use of black chert and greater reliance on other chert types and orthoquartzite. In fact, orthoquartzite was twice as common in plateau contexts compared with sites in the valley (Figures 5.24 and 5.25). It is possible that many of these materials, including the cryptocrystalline black chert, occur naturally in this setting as glacial float pebbles and cobbles and were procured by people as they travelled through.

It was also observed that much of the debitage from HaRj-32 consists of tertiary reduction flakes, which suggests people were bringing finished tools or preforms to this location and reworking or re-sharpening them as necessary. It is also possible that the small pieces of debitage reflect conservation of lithic materials in a setting where reliable sources of tool stone are variable or uncertain. Conservation of lithic raw materials has also been linked to microblade technology, where people adopted this reduction strategy in an effort to maximize suitable cutting edges with a minimum of lithic raw material expenditure (Clark 2001). Microblades and associated blade cores (discussed below) were identified at HaRj-32 and HaRf-32, both located on the transmission line corridor.

While no source locations have been documented for the black chert or the other varieties, it is likely that most artifacts are made from locally available chert cobbles found in fluvial gravel deposits and eroding out of creek and river drainages (Spurling 1980b). Spurling further notes that while no efforts were made by SFU crews to locate bedrock sources or quarry locations for chert, local informants mentioned a possible quarry site in the Sikanni Chief locale, approximately 140 km north of the LAA. This location was also disclosed to one of the authors by a community member during the 2011 field season, as a location where chert could be obtained for tool making.

5.2.5.1.4.2 Obsidian

Obsidian artifacts were recovered from 12 sites in the LAA (Figure 5.26). Eight of the sites are located in the Peace River valley (HaRk-23, HaRk-46, HbRg-5, HbRg-11, HbRh-36, HbRh-122, HbRh-144, and HbRi-43) and four are within the transmission line corridor (GlRj-2, HaRf-32, HaRg-37, and HaRj-32). The obsidian assemblage from these sites is represented by 59 pieces of debitage, 13 macroblade fragments, three uniface fragments, and one microblade core. Sixty-six of the obsidian specimens were sent to the Northwest Obsidian Research Laboratory (Corvallis, Oregon) for trace element characterization and location of source flows (Appendix G). Six sources were identified using X-ray fluorescence analysis, five of which are from known obsidian flows:

- Mt. Edziza 2, British Columbia
- Mt. Edziza 3, British Columbia
- Ilgachuz, British Columbia
- Anahim Peak, British Columbia
- Bear Gulch, Idaho.

An unknown source material was found in association with three Mt. Edziza obsidian artifacts, suggesting that these likely are also from the Mt. Edziza volcanic field (Skinner and Thatcher 2011, Appendix G).

The Mt. Edziza volcanic field is situated in northwestern British Columbia, in the Stikine River basin approximately 600 km straight-line distance from the LAA. Despite the considerable distance to the source location from the Peace region, the presence of this widely traded material in the LAA was expected based on previous field work in the Peace River valley that had recovered artifacts manufactured from Mt. Edziza obsidian (e.g., Spurling 1980b). Artifacts made from Mt. Edziza obsidian have been recovered in significant frequencies from sites in the Williston Reservoir drawdown zone (Arcas 2003; Millennia 2010) as well as various sites in British Columbia and Alberta (Carlson 1994).

The occurrence of Anahim and Ilgachuz obsidian in the region is not entirely unexpected. The two source flows are located approximately 30 km apart, in the western Chilcotin Plateau, approximately 500 km southwest of the LAA. Carlson (1994) notes that obsidian from these Chilcotin sources has been found in archaeological contexts throughout much of British Columbia over most of the Middle and Late Prehistoric periods (ca. 6,000 to 150 BP), providing indications for the early establishment of interregional trade networks. In addition, Godfrey-Smith and Magne (1988) note that the co-occurrence of Anahim and Mt. Edziza obsidians at archaeological sites in British Columbia and Alberta is not uncommon and has been observed on numerous occasions.

The presence of obsidian from the Bear Gulch source location in southeastern Idaho was more interesting, since the parent flow is more than 1,400 km away. Previously known as British Columbia Southern Interior A (BCSIA) (James, et al. 1996), Bear Gulch obsidian has been identified in archaeological assemblages from central and southern Alberta (Godfrey-Smith and Magne 1988; Peck 2011) and southeastern British Columbia, while only a single specimen had previously been identified in northeastern British Columbia (Carlson 1994).

The presence of obsidian from distant sources strongly suggests that interregional exchange systems were in place at the time the sites were created. Spurling (1980b) noted it was likely that trade between groups on the Northern Plains and those residing in Central Interior and Coastal regions of British Columbia had existed over a long period of time, and Aboriginal communities in the Peace region were well situated to serve as intermediaries for the exchange of goods. This scenario may explain the presence of Bear Gulch obsidian in the Peace region, as the distance between the source and the site where this material was found is considerable.

5.2.5.2 Analysis of Faunal Remains

A total of 2,309 bones, bone fragments, teeth, and mollusc shells were collected from 46 archaeological and historical sites (Table 5.20 and 5.21). The most commonly identified class of animal was mammal, with 2,096 bones, teeth, or bone fragments identified. Twelve bird bones were identified, as was one fish bone. Sixteen invertebrate remains (i.e., freshwater molluscs) were also identified. A further 184 specimens represent bones so fragmented they could not be confidently assigned to class, but likely represent bird or mammal.

Seven distinct mammal species were identified in the assemblage, with the most commonly identified taxon being snowshoe hare (*Lepus americanus*; NISP = 16). These bones came from four sites (HaRj-14, HaRj-23, HaRk-49, HbRh-8, HbRh-36, and HbRh-142. Deer (*Odocoileus sp*.; NISP = 4) were the next most commonly identified species, and were recovered from four sites (HbRf-115, HbRg-53, HbRg-55, and HbRh-12). Two bones were identified as wapiti or elk (*Cervus canadensis*). These were recovered from HaRk-49 and HbRh-131. One black bear (*Ursus americanus*) bone was identified from HaRj-14, one bison (*Bison sp*.) bone from HaRk-38, and mink (*Mustela vison*) and muskrat (*Ondatra zibethicus*) were identified from single bones at HbRh-8. The vast majority of mammal bones (2,065; 99%) are fragmented and could not be identified to species. Of these, 13 represented artiodactyls, 2 represented bovid (bison or domestic cattle), 15 represented large ungulates (i.e., bison, domestic cattle, moose, or elk), and 1 represented a rodent or rabbit.

Bird bones were identified at five sites (GlRj-2, HaRk-23, HaRk-32, HbRg-53, and HbRh-61). Just three of these bones were identified to species. A spruce grouse (*Canachites canadensis*) was identified at HaRk-23, a Canada goose (*Branta canadensis*) was identified at the historical site of HaRk-32, and a sandhill crane (*Grus canadensis*) at HbRg-53. At HaRk-32 the bone of a duck (family Anatidae) was also recovered, but could not be assigned to a species.

One fish bone, the vertebra of a northern pikeminnow (*Ptychocheilus oregonensis*), was recovered from GlRj-2 located at the south edge of Boucher Lake. This fish is distributed primarily west of the Continental Divide, but also to its east in the Peace River drainage system. Northern pikeminnow prefer lakes to swift waters, but are not uncommon in rivers (Scott and Crossman 1973).

Invertebrate remains included 15 shells of common stagnicola (*Stagnicola elodes*), a ubiquitous mollusc which occupies a variety of aquatic habitats, particularly in thick vegetation or muddy substrates (Clarke 1981). These shells were collected from HaRj-34. Another shell, a lake stagnicola, (*Stagnicola catascopium*), was collected from a deep test at HaRk-23. This species is widespread across North America and a characteristic inhabitant of large lakes and rivers (Clarke 1981). These molluscs likely do not represent food items, but are incidental inclusions into the archaeological record.

Table 5.20: Identified faunal species

Class	Species	Common Name	NISP
Mammalia	*Lepus americanus*	Snowshoe hare	16
	Odocoileus sp.	Deer	4
	Cervus canadensis	Wapiti or elk	2
	Ursus americanus	Black bear	1
	Bison sp.	Bison	1
	Mustela vison	Mink	1
	Ondatra zibethicus	Muskrat	1
Aves	*Canachites canadensis*	Spruce grouse	3
	Branta canadensis	Canada goose	1
	Grus canadensis	Sandhill crane	1
Osteichthyes	*Ptychocheilus oregonensis*	Northern pikeminnow	1
Gastropoda	*Stagnicola elodes*	Fresh water snail Common stagnicola	15
	Stagnicola catascopium	Lake stagnicola	1

NOTES:
NISP – number of identified specimens present

Three-quarters (*n* = 1,727; 75%) of all fauna remains show evidence of being burnt. The majority of these burnt bones (*n* = 1,506; 87%) are calcined, or had been burned at such a high temperature that they appear white (Reitz and Wing 2008). Burnt bones were recovered from HaRg-38, HaRj-14, HaRj-19, HbRg-47, HbRg-50, HbRh-16, HbRh-8, and HbRi-58. Calcined bones were recovered from HaRf-27, HaRf-35, HaRk-1, HaRk-35, HaRk-49, HaRl-29, HbRf-8, HbRf-115, HbRh-36, HbRi-6, HbRi-10, and HbRi-43. Both burnt and calcined bones were recovered from GlRj-2, HaRf-34, HaRk-23, HaRk-38, HaRk-46, HaRk-50 HbRi-12, and HbRh-54. One mammal bone fragment from HbRf-115 appeared to have no remaining collagen, suggesting it had been boiled, although natural mineral loss (i.e., diagenesis) could also be a factor (Lyman 1994).

Spiral fractures consistent with Pre-contact butchering practices were observed on 10 bones. These included a bison tibia recovered from HaRk-38, as well as a deer humerus from HbRf-115. Long bone fragments from HbRg-47 and HbRh-131, as well as fragments from GlRj-2 and HaRk-50 also exhibited spiral fractures. Five bone fragments—one each from HaRg-38, HbRf-115, HbRg-50, HbRh-131, and HbRi-12—appear to have been smashed or splintered, potentially to gain access to marrow (Lyman 1994). One bone fragment from HaRk-46 appears to have been spirally fractured and smashed.

Evidence of post-contact butchery (e.g., sawing) was evident on six bones from two sites. One artiodactyl rib and four other fragments from HaRk-49 showed evidence of sawing, as did the atlas fragment of a bison or cow from HbRf-115. Fauna was recovered from three previously identified historical sites (HaRk-32, HbRf-8, and HbRh-61). In addition to the evidence for sawing at the above sites, historical or recent artifacts and Pre-contact artifacts were recovered in context with fauna in association from HaRk-49 and HbRg-53.

Nearly half the bones and fragments came from one site: HaRk-23 (*n* = 1,138; Appendix N-2, Photograph 46). Other sites with large amounts of bone include GlRj-2 (*n* = 124, HaRf-34 (*n* = 515), HaRk-46 (*n* = 100), and HbRh-36 (*n* = 116). Given the fragmented nature of faunal remains recovered from the LAA, it is difficult to assess how diverse the assemblages are. However, multiple species were identified at several sites. At HaRk-23, the assemblage includes a large ungulate, medium-sized mammal, and spruce grouse. At HbRh-8, snowshoe hare, mink, and muskrat were identified.

While few species were identified overall, they are consistent with documented Aboriginal hunting practices for large mammals, hares, and other fur-bearers, as well as game birds (e.g., Goddard 1916; Ridington 1981; Brody 1988). No European domesticates were conclusively identified; however, it is likely that sawn bovid specimens represent cattle. Bear and fur-bearers have been identified in previous studies in the region (e.g., Hamilton, et al. 1988; Driver, et al. 1996; Archer 2009a, 2009b), and black bear, mink, muskrat, as well as snowshoe hare were identified here. Extinct and extirpated species have been recorded in Late Pleistocene – Early Holocene archaeological and natural deposits in the Peace region (e.g., Driver 1988; Apland and Harington 1994; Driver, et al. 1996), but no evidence of these species was conclusively identified by the field program, with the exception of a bison tibia that was collected.

Previous excavations in the Peace River valley in 1977 and 1978 by SFU (Fladmark 1980; Spurling 1980b) at HaRk-1 resulted in the identification of 10 species. These included snowshoe hare, black bear, elk, and deer, species which were also identified during the current study. Species identified from the SFU excavations which were not identified in the current study include chipmunk (*Eutamias affinis*), beaver (*Castor canadensis*), deer mouse (*Peromyscus sp.*), field vole (*Microtus sp.*), porcupine (*Erethizon dorsatum*), and moose (*Alces alces*).

While bone tools, including moose horn knives, beaver tooth tools, and moose bone fleshers were ethnographically used by the Beaver (Goddard 1916), and a bone awl was recovered from the 1977 to 1978 excavations at HaRk-1 (Spurling 1980b), no conclusive evidence for tools of bone or ornamental items made of bone, tooth, or shell was recovered.

Generally speaking, Peace River valley faunal assemblages are dominated by unidentifiable bone fragments, in many cases burnt or calcined (e.g., Fladmark 1980; Spurling 1980b; Alexander 1982). The fauna recovered from the field program are consistent with material recovered in other studies in the Peace region. While most of the collection is unidentifiable, it is also largely consistent with the ethnographic record for the hunting of large ungulates in the Peace region. Although no identifiable moose bone was recovered, large ungulate remains and burnt and calcined mammal fragments are comparatively abundant at some sites, including HaRf-34, and HaRk-23. According to ethnographic accounts, primary butchery of moose occurred at the kill site, with portions distributed among hunters there and portions either taken back to camp or cached (e.g., Goddard 1916; Ridington 1981; Brody 1988). While the fragmented nature of much of the bone in the Peace River valley archaeological record has been interpreted as poor preservation (Fladmark 1980; Spurling 1980b), human

agency may also have been a factor. Bones could have been broken for marrow and grease extraction (e.g., Lyman 1994). Ethnographers report that supplying the two pounds of meat per day required per person was often difficult (Ridington 1981; Brody 1988). It is known that processing for marrow and bone grease extraction to maximize food resources was common during the Pre-contact period which would result in pulverized and highly fragmented bone. Burnt bone, which is abundant in the assemblage, is consistent with cooking as well as disposal of food waste (Reitz and Wing 2008).

Table 5.21: Faunal remains recovered during the archaeological field program

Site	Test No.	DBS	Fauna Recovered
GlRj-2	45642	10 – 20	2 burnt bone fragments (1 with possible spiral fracture), medium-large mammal
	45442	11	5 calcined bone fragments, medium-large mammal
	45322	5	1 calcined bone fragment, unidentified
	45194	30	1 calcined bone fragment, medium-large mammal 2 burnt bone fragments, medium-large mammal
	45410	20	1 calcined bone fragment, bird, 3 bone fragments, mammal
	45478	10 – 20	1 bone fragment, mammal
	45422	40	1 bone fragment, mammal
	45382	20	1 bone fragment, mammal
	45377	10 – 15	2 tooth fragments, artiodactyl
	45424	10 –20	3 burnt bone fragments, medium-large mammal
	45381	15	1 bone fragment (petrified)
	45470	10 – 20	1 burnt bone fragment, mammal
	45429	10 – 20	11 burnt bone fragments, medium-large mammal
		20 – 40	86 calcined bone fragments, medium-large mammal
	42863	10	1 vertebra, northern pikeminnow (*Ptychocheilus oregonensis*)
	45404	20	1 bone or tooth fragment (petrified), mammal
HaRf-27	18826	40 – 42	2 calcined bone fragments, mammal
HaRf-34	45690	0 – 55	4 bone fragments (degraded), large mammal
	45642	0 – 50	8 bone fragments (degraded), large mammal
	45692	0 – 50	92 bone fragments (degraded), large mammal
	45688	0 – 50	27 bone fragments (degraded), medium-large mammal
	45694	0 – 50	10 bone fragments (degraded), large mammal
	34251	11 – 50	17 bone fragments (degraded), medium-large mammal
	34256	11 – 50	12 burnt bone fragments (degraded), medium-large mammal
	34270	25	7 burnt bone fragments (very degraded), medium-large mammal
	34253	4 – 50	18 calcined bone fragments, medium-large mammal

Site	Test No.	DBS	Fauna Recovered
	34256	11 – 50	19 bone fragments(degraded), large mammal
	34260	NA	38 calcined bone fragments(degraded), medium-large mammal
	45678	All layers	30 calcined bone fragments, medium-large mammal
	45683	5 – 30	32 bone fragments(very degraded), medium-large mammal
	45677	All layers	90 calcined bone fragments (very degraded), medium-large mammal
	45675	5 – 28	34 bone fragments (very degraded), medium-large mammal
	45685	All layers	20 fragments, mammal, medium-large (very degraded)
	45687	All layers	4 calcined bone fragments (very degraded), medium-large mammal
	45682	3 – 25	13 calcined bone fragments (very degraded), medium-large mammal
	45676	All layers	40 bone fragments (very degraded), large mammal
HaRf-35	33337	50	1 calcined bone fragment, medium-large mammal
HaRg-38	45628	4 – 20	1 burnt fragment (splintered), medium-large mammal
HaRg-40	34677	4 – 33	1 tooth fragment, large ungulate
HaRj-7	41031	5 – 10	1 rib, large artiodactyl
HaRj-14	45443	40 – 50	1 lumber vertebra, snowshoe hare (*Lepus americanus*) 1 femur, snowshoe hare 1 distal femur, snowshoe hare 1 small mammal long bone fragment
	45486	0 – 5	1 metatarsal bear (*Ursus americanus*)
HaRj-19	AT-10	0 – 35	2 burnt bone fragments, unidentified
HaRj-34	45145	30 – 40	15 freshwater snails (common stagnicola [*Stagnicola elodes*])
HaRk-1	42863	5 – 15	4 calcined bone fragments
	45893	10 – 15	1 fragment, artiodactyl tooth
	45859	35	3 fragments, cranial bones, mammal
HaRk-16	Trench 2	125 – 150	1 long bone fragment with impact scar, large mammal,

Site	Test No.	DBS	Fauna Recovered
HaRk-23	Trench 2	100 – 125	4 bone fragment, medium-large mammal
			4 bone fragments, calcined
			45 calcined bone fragments, medium-large mammal
			1 burnt bone fragment, rib, large bovidae – cervidae
			1 freshwater mollusc shell, lake stagnicola (*Stagnicola catascopium*)
		125 – 160	586 calcined bone fragments, large mammal
			1 burnt bone fragment, large mammal
			1 calcined bone fragment, lumbar vertebra, large ungulate
			1 calcined bone fragment, thoracic vertebra, large ungulate
			1 burnt fragment, scapula, ungulate large
			4 calcined fragments, vertebra, ungulate, large
			207 calcined bone fragments, medium-large mammal
			65 burnt bone fragments, medium-large mammal
			81 bone fragments, medium-large mammal
			1 calcined bone fragment, rib, medium-large mammal
			1 calcined bone fragment, rib, mammal, medium
			2 calcined bone fragments, acetabulum, medium mammal
			1 calcined bone fragment, tibia, medium mammal
			1 proximal coracoid, spruce grouse (*Canachites canadensis*)
			1 calcined bone fragment, vertebra, bird
			1 calcined bone fragment, long bone, bird
			1 fragment, long bone, bird
			127 calcined bone fragments, unidentified
HaRk-32 (Historic site)	1	0 – 20	1 bone fragment, rib, bird
		40 – 50	1 right humerus (duck) 1 left femur Canada goose (*Branta canadensis*)
HaRk-35	31225	15 – 35	6 calcined bone fragments mammal
HaRk-38	JT-46	5 – 35	7 burnt bone fragments 1 burnt bone fragment from a medium-to-large sized mammal
	61	20 – 25	11 bone fragments, medium-large mammal 1 spirally fractured distal medial tibia, bison
	45779	0 – 10	2 burnt fragments, medium-large mammal 4 calcined fragments, medium-large mammal
		10 – 20	3 calcined bone fragments, medium-large mammal
	45792	15 – 25	24 burnt bone fragments, medium-large mammal

Site	Test No.	DBS	Fauna Recovered
HaRk-46	31183 – EU 2	40 – 60	6 calcined bone fragments, unidentified 1 fragment, unidentified 2 burnt bone fragments, large mammal (SE quad) 18 calcined fragments, medium-large mammal 15 fragments large mammal
	31183 – EU 2	50 – 60	2 calcined bone fragments, mammal
	31183 – EU 2	50 – 55	1 bone fragment with impact scar and possible cut mark, large mammal
	31183	40 – 55	4 burnt fragments, medium-large mammal 6 fragments, medium-large mammal 13 calcined fragments, mammal
	31183	43 – 50	3 fragments, medium-large mammal 5 calcined fragments, mammal 1 calcined fragment, unidentified
	EU 2	50	8 burnt fragments, large mammal 11 calcined fragments, unidentified 1 fragment, unidentified 1 fragment (associated with fire-altered rocks), large mammal
	Trench 2	75 – 100	2 calcined fragments, mammal
HaRk-47	41585	14 – 16	1 fragment, large mammal
	41481	10 – 15	1 fragment, scapula, medium-large artiodactyl 1 sesamoid, medium-large artiodactyl 1 lower molar (plough zone), medium artiodactyl
HaRk-49	43077	3	1 mandibular canine, elk
	45384	5	1 fragment, sawn, rib, artiodactyl 1 fragment, sawn, large mammal 1 fragment (historical artifact), medium-large mammal
		20	3 sawn fragments, large mammal 1 fragment, large mammal
	NA	15 – 20	9 calcined fragment, medium-large mammal
	45240	20	1 fragment, medium-large mammal 1 mandible fragment, snowshoe hare
	45399	5	1 fragment, mammal
	45406	5	1 vertebra fragment, large mammal
HaRk-50	45504	50 – 60	3 fragment, medium-large mammal 6 calcined fragment, medium-large mammal 2 burnt fragment, long bone, large mammal 4 burnt fragment, long bone with spiral fracture, large mammal 16 burnt fragments, medium-large mammal
HaRk-53	ST3	0 – 10	1 fragment, rib, medium-large mammal, (may be historic)

Site	Test No.	DBS	Fauna Recovered
HaRl-29	AT-10	5 – 20	2 phalanges, unidentified 10 calcined fragments, unidentified
HbRf-8 (Historic site)	ST-6	0 – 5	1 calcined bone fragment, mammal
HbRf-115	44268	0 – 5	1 calcined bone fragment, medium-large mammal,
	44372	0 – 5	1 smashed bone fragment, possibly boiled (lacks collagen), mammal
	44268	Surface	1 distal left humerus with spiral fracture, deer
	44405	Provenance unknown	1 sawn fragment, atlas, cow (*Bos taurus*) or bison
HbRg-5	31684	25 – 30	1 molar, large ungulate 1 molar fragment, large ungulate 1 maxilla fragment, large ungulate 4 fragments, medium-large mammal
HbRg-15	16090	0 – 8	1 fragment, mammal 1 vertebral epiphysis, artiodactyl (likely deer [*Odocoileus sp.*])
HbRg-47	28213	12 – 34	2 burnt fragments, mammal
	28205	0 – 43	7 burnt fragments, large mammal 1 fragment (spiral fractured), mammal
	16426	50	1 scapula fragment, medium sized mammal 5 fragments, medium-large mammal,
HbRg-50	AT 28318	10 – 20	1 fragment, large mammal 1 fragment with impact scar, large mammal
HbRg-53	36699	30 – 40	1 innominate fragment, deer (*Odocoileus sp.*) 1 mandible fragment, artiodactyl (historic disturbance)
	45438	32	1 metacarpal distal condyle, *Bos* or *Bison*
	45439	20 – 30	1 cranial fragment, artiodactyl (historic artifacts)
	45395	0 – 10	1 rib fragment, artiodactyl
	45427	15	2 rib fragment, large mammal
		30	1 bone fragment, large mammal
	45392	0 – 10	1 femur, Sandhill Crane (*Grus canadensis*)
HbRg-55 (MVT Judge)	Judgemental– 1	NA	1 complete right lunate, deer (*Odocoileus sp.)*
HbRh-12	45999	25 – 30	1 tibia fragment, small mammal 2 long bone fragment, small mammal
	45883	5	1 left metacarpal deer (*Odocoileus sp.*)
HbRh-16	44820	10 – 30	9 burnt bone fragments, um-large mammal

Site	Test No.	DBS	Fauna Recovered
HbRh-8 (incorporating former area of HbRh-27)	45699	30	3 proximal tibia, snowshoe hare 1 innominate fragment, snowshoe hare 2 metapodial, snowshoe hare 2 phalanx, snowshoe hare 1 humerus, muskrat (*Ondatra zipethicus*) 1 innominate fragment, mink (*Mustela vison*) 1 long bone fragment, bird or mammal 1 metapodial, small mammal 6 phalanx, small mammal 1 tooth fragment, rodent or lagomorphs 19 bone fragments, small mammal 2 long bone fragments, small mammal
	45741	Missing	1 long bone fragment, small mammal
HbRh-36	29097	0 to 20	115 calcined bone fragments, mammal
	45827	5	1 mandible, snowshoe hare
HbRh-54	45749	10	2 burnt bone fragments, medium-large mammal 2 calcined bone fragments, medium-large mammal 6 bone fragments, medium-large mammal,
HbRh-61 (Historic site)	NA	0 – 5	1 bone fragment, unidentified bird
HbRh-131	29035	5 – 20	1 fragment, long bone (spirally fractured), mammal 1 sesamoid fragment, medium-large sized artiodactyl
	29034	10	1 left radius, elk (*Cervus canadensis)*
	EU 1	45	6 fragments, long bone, mammal
HbRh-142	37069	10	1 left mandible, snowshoe hare 1 right mandible, snowshoe hare
HbRh-148	45908	0 – 10	1 metapodial fragment, large mammal,
HbRi-6	45175	20 – 25	8 calcined bone fragments, mammal 1 bone fragment, mammal
HbRi-10	AP-108	NA	1 innominate fragment, medium-sized artiodactyl (most likely deer)
	25	20 – 30	1 calcined bone fragment, mammal
	Point 1	Surface	1 calcined fragment, mammal
	Point 24	20 – 50	2 calcined bone fragments, mammal
	46344	10 – 15	2 fragments, long bone, mammal
HbRi-12	46405	5 – 10	2 bone fragments, mammal
	46413	10 – 20	2 calcined bone fragments, mammal
	46374	15 – 30	1 burnt fragment (pulverized) long bone, mammal
HbRi-43	21837	0 – 10	1 calcined bone fragment
HbRi-56	28178	0 – 5	1 bone fragment, likely blade of scapula or innominate, large mammal
HbRi-58	21818	5 – 40	1 burnt bone fragment

NOTES:
DBS – Depth below surface
NA – data not available

5.2.5.3 Radiocarbon Analysis

The following section discusses newly processed and previously obtained radiocarbon samples from archaeological sites within the LAA. Further details on the sites from which the samples were collected are presented in the site summaries in Appendix F.

For the current heritage assessment program, 7 charcoal and 23 bone samples were submitted to Beta Analytic Inc. (Beta) for Accelerator Mass Spectrometry radiometric dating (Table 5.22; Appendix H). Four bone samples, from sites GlRj-2, HaRk-38, HbRh-16, and HbRh-54, did not contain enough bone collagen to provide a date. Further, Beta terminated analysis of a sample from HaRk-50 when roots, a likely contaminant, were observed mixed with the sample. Thus, 25 samples were fully processed, providing conventional dates ranging from "modern" to 4,620 Radiocarbon Years before Present (BP) (Figure 5.27).

Five dates potentially fall under the modern or historic period. One bone sample from HbRi-10 (200 ± 40 BP; Beta-306780) potentially dates to either the terminal Pre-contact or the modern period at its two-sigma (i.e., 95%) probability range. Calibration curves indicate that this sample may be as old as 310 BP and as young as 0 BP. Despite being recovered from a depth of 32 cm below surface, a bone sample from HaRf-34 produced a modern conventional date of 40 ± 30 BP (Beta-330002), which has not been calibrated. Two bone samples from HbRh-12, recovered from Pre-contact artifact-bearing sediments, also resulted in modern conventional dates: 50 ± 30 BP (Beta-330008) and 135.3 ± 0.3 pMC[6] (Beta-330009) which have not been calibrated. A sample of snowshoe hare bones associated with lithic artifacts recovered from 25 to 30 cm below surface at HaRj-23 produced a conventional age of 130 ± 30 BP (Beta-330005), providing a calibrated two sigma range of 280 to 0 BP. Based on the radiocarbon results alone, it is most likely that fauna from HaRf-34 and HbRh-12 are intrusive, resulting in modern dates. HbRi-10 has both a Pre-contact and post-contact (historical) component so the radiocarbon date for this site could be attributable to either a late Pre-contact occupation or the historical occupation of this site. With respect to HaRj-23, the snowshoe hare remains could be associated with a late Pre-contact occupation of this site or are a modern intrusion (e.g., hare burrow).

Dates from HaRj-14 (2,440 ± 30 BP; Beta-330006), HaRk-16 (2,870 ± BP; Beta-330451), HbRh-8 (1,840 ± 30 BP; Beta 330011), and HbRh-12 (135.3 ± 0.3 pMC; Beta-330009) were derived from bone samples with lower than normal carbon levels and, as a result, may reflect dates that are younger than their actual age (Patrick 2012, pers. comm.). With the exception of the modern date from HbRh-12, these lower carbon dates are consistent with artifact assemblages exclusively comprised of lithic artifacts. However, it is notable that a second bone sample from HbRh-12, for which lower than normal carbon was not considered an issue, also produced a younger than expected age (50 ± 30 BP; Beta 330008).

Multiple dates were obtained from two sites during deep testing in 2012. These results suggest that HaRk-16 and HaRk-23 are both multi-component sites, each potentially occupied at least three times over a thousand-year period. Charcoal obtained from 55 cm below surface in Trench 1 at HaRk-16 produced a date of 1,840 ± 30 BP (Beta-330449). Another charcoal sample from 105 cm below surface in the same trench dated to 2,420 ± 30 BP (Beta-330450). The oldest date from HaRk-16 (Beta-330451) came from Trench 2 and was 2,870 ± BP,

[6] Percent modern carbon, calculated against a reference sample of natural C-14 activity from 2010950.

more than 1,000 years earlier than the youngest date from this site. Lower than normal carbon levels from this bone sample may mean that it is actually older than this radiocarbon date suggests.

Similar results were obtained from HaRk-23. The youngest date from this site, 1,250 ± 30 BP (Beta-330452), came from charcoal in Trench 1 at 45 cm below surface. From Trench 2 at HaRk-23, a date of 2,200 ± 30 BP (Beta-330454) was obtained from calcined bone at 125 to 160 cm below surface. Calcined bone from a higher level in the trench (100 to 125 cm) produced an older date of 2,280 ± 30 BP (Beta-330453). While inverted deposits are a possible interpretation of this result, calibrated dates for both sites overlap between 2,330 and 2,300 BP, and may also be interpreted as a more refined date of the older occupation.

Table 5.22: Radiocarbon dating results

Sample No.	Lab No.	Site	Test No.	Context	Material	Conventional Date[a]	Calibrated Date[b]	Calibrated Calendric Date
ASLP122-1	330003	GlRj-2	45420	Burnt bone fragments, 10 to 20 cm below surface	Bone	No bone collagen present after pre-treatment; could not be dated	NA	NA
ASLP122-2	330004	GlRj-2	45420	Calcined bone fragments, 20 to 40 cm below surface	Bone	3,330 ± 40 BP	3,680 – 3,660 BP 3,640 – 3,460 BP	1730 – 1710 BC 1690 – 1510 BC
ARD121145677	330002	HaRf-34	45677	32 cm below surface, fragments of bone throughout test	Charcoal	40 ± 30 BP	NA	NA
HARJ14-45443	330006	HaRj-14	45443	Snowshoe hare long bones and vertebra with some burning, 40 to 50 cm below surface	Bone	2,440 ± 30 BP * Date may be biased towards younger	2,700 – 2,630 BP 2,620 – 2,560 BP 2,550 – 2,360 BP	750 – 680 BC 670 – 610 BC 600 – 400 BC
GMY129-45172	330005	HaRj-23	45172	Snowshoe hare pelvic bone, 25 to 30 cm below surface, at similar depth to artifacts at site	Bone	130 ± 30 BP	280 – 170 BP 150 – 50 BP 50 – 0 BP 0 BP – post-1950	1670 – 1780 AD 1800 – 1900 AD 1900 – 1940 AD 1950 – post-1950

Sample No.	Lab No.	Site	Test No.	Context	Material	Conventional Date[a]	Calibrated Date[b]	Calibrated Calendric Date
HARK16T155	330449	HaRk-16	Trench 1	55 cm below surface; trench is immediately south of ST 25033, no associated artifacts or fauna, but believed to be associated with other deposits at HaRk-16 and cultural layers at HaRk-23	Charcoal	1,840 ± 30 BP	1,860 – 1,710 BP	80 – 240 AD
HARK16T1105	330450	HaRk-16	Trench 1	105 cm below surface; trench is immediately south of ST 25033, no associated artifacts or fauna, but believed associated with and other deposits from HaRk-16 and cultural layers at HaRk-23	Charcoal	2,420 ± 30 BP	2,690 – 2,640 BP 2,610 – 2,600 BP 2,500 – 2,350 BP	740 – 690 BC 660 – 650 BC 550 – 400 BC
HARK16-T2125	330451	HaRk-16	Trench 2	125 to 150 cm below surface; no artifacts, but believed associated with and other deposits from HaRk-16 and cultural layer at HaRk-23	Bone	2,870 ± 30 BP * Date may be biased towards younger age	3,080 – 2,920 BP 2,910 – 2,890 BP	1130 – 970 BC 960 – 940 BC
HARK23T145	330452	HaRk-23	Trench 1	From 45 cm below surface, not associated with fauna or artifacts, but believed to be related to Trench 2 cultural material	Charcoal	1,250 ± 30 BP	1,270 – 1,120 BP 1,110 – 1,080 BP	680 – 830 AD 840 – 870 AD

Sample No.	Lab No.	Site	Test No.	Context	Material	Conventional Date[a]	Calibrated Date[b]	Calibrated Calendric Date
HARK23T2100	330453	HaRk-23	Trench 2	Calcined bone fragments, 100 to 125 cm below surface, 5 m south of ST 25212 in Lift 5, associated with additional fauna and artifacts	Bone	2,280 ± 30 BP	2,350 – 2,300 BP 2,240 – 2,180 BP	400 – 350 BC 290 – 230 BC
Hark23T2125	330454	HaRk-23	Trench 2	Calcined bone fragments, 125 to 160 cm below surface, 5 m south of ST25212 in Lift 6; associated with additional fauna and artifacts, including obsidian	Bone	2,200 ± 30 BP	2,330 – 2,130 BP	380 – 180 BC
AJKT46-2025	306773	HaRk-38	61	Bison tibia fragment, 20 to 25 cm below surface	Bone	2,870 ± 40 BP	3,140 – 3,090 BP 3,090 – 2,870 BP	1190 – 1140 BC 1140 – 920 BC
HARK38-45792	330007	HaRk-38	45792	Burnt mammal bone fragments from edge of site, 15 to 25 cm below surface	Bone	No bone collagen present after pre-treatment; could not be dated	NA	NA
GDD6EU2-5055	306778	HaRk-46	EU 2	Unburnt bone fragment, 50 to 55 cm below surface; associated with fire-altered rock	Bone	1,710 ± 40 BP	1,710 – 1,530 BP	240 – 420 AD
GDD6EU2-58	306772	HaRk-46	EU 2	Sample collected with soil, 58 cm below surface; lithics extend to 60 cm below surface	Charcoal	1,700 ± 40 BP	1,710 – 1,530 BP	240 – 420 AD
GDD6EU1-55	306771	HaRk-46	EU 1	Sample collected with soil, 55 cm below surface; artifacts extend to 60 cm below surface	Charcoal	1,780 ± 40 BP	1,820 – 1,600 BP	130 – 350 AD

Sample No.	Lab No.	Site	Test No.	Context	Material	Conventional Date[a]	Calibrated Date[b]	Calibrated Calendric Date
ADH122-45504	330001	HaRk-50	45504	Burnt large mammal long bone fragments, from 50 to 60 cm below surface	Bone	No bone collagen present after pre-treatment; burnt bone organics mixed with roots; testing halted by Beta	NA	NA
GCT16437	306775	HbRg-47	29025	0 to 43 cm below surface in plough zone; bone is a long bone fragment with a spiral fracture from butchery; artifacts in same test	Bone	4,410 ± 40 BP	5,270 – 5,180 BP 5,060 – 4,860 BP	3320 – 3230 BC 3110 – 2910 BC
ARDT7-28329	306774	HbRg-50	28329	Large fragment of mammal bone, 10 to 20 cm below surface	Bone	1,330 ± 40 BP	1,300 – 1,180 BP	640 – 770 AD
HBRH12-45999	330009	HbRh-12	45999	Small mammal long bone fragments, 25 to 30 cm below surface; debitage found at same level in test	Bone	135.3 ± 0.3 pMC (modern) *Date may be biased towards younger age	NA	NA
HBRH12-45883	330008	HbRh-12	45883	Deer metacarpal from 5 cm below surface, same depth as artifacts in surrounding tests	Bone	50 ± 30 BP	NA	NA
HBRH16-44820	330010	HbRh-16	44820	Fragments of burnt mammal bone, 10 to 30 cm below surface	Bone	No bone collagen present after pre-treatment; could not be dated	NA	NA
HBRH27-45699	330011	HbRh-8	45699	Rabbit long bones and vertebra, found in association with bones of two other fur-bearers	Bone	1,840 ± 30 BP *Date may be biased towards younger age	1,860 – 1,710 BP	80 – 240 AD

Sample No.	Lab No.	Site	Test No.	Context	Material	Conventional Date[a]	Calibrated Date[b]	Calibrated Calendric Date
GKCT1-29097	306779	HbRh-36	29097	0 to 20 cm below surface; artifacts at same depth as well as in shallower and deeper contexts	Bone	2,040 ± 40 BP	2,120 – 1,900 BP	170 BC – 50 AD
HBRH54-45749	330012	HbRh-54	45749	Unburnt mammal fragments; found in association with burnt and calcined bones, 10 cm below surface	Bone	No bone collagen present after pre-treatment; could not be dated	NA	NA
HBRH55-45802	330013	HbRh-55	45802	20 cm below surface, between artifact-bearing levels; burnt root noted in south wall, but was believed to be separate	Charcoal	2,130 ± 30 BP	2,300 – 2,270 BP 2,160 – 2,040 BP 2,030 – 2,000 BP	350 – 320 BC 210 – 90 BC 80 – 50 BC
GCDT329035	306777	HbRh-131	29035	5 to 20 cm below surface; unburnt ungulate bone with 126 artifacts at the same depth in the same test	Bone	320 ± 40 BP	490 – 290 BP	1460 – 1660 AD
GCDT3EU1-45	306776	HbRh-131	EU 1	One of several long bone fragments 45 cm below surface; below artifact-bearing level, 5 to 10 cm below surface	Bone	2,820 ± 40 BP	3,030 – 2,850 BP	1080 – 900 BC
HBRI6-45175	330014	HbRi-6	45175	Calcined bone fragments, 20 to 25 cm below surface	Bone	4,620 ± 40 BP	5,460 – 5,370 BP 5,360 – 5,360 BP 5,350 – 5,350 BP 5,330 – 5,330 BP	3510 – 3420 BC 3420 – 3410 BC 3400 – 3400 BC 3380 – 3350 BC

Sample No.	Lab No.	Site	Test No.	Context	Material	Conventional Date[a]	Calibrated Date[b]	Calibrated Calendric Date
MKBHBRI10108	306780	HbRi-10	AP-108	0 to 20 cm below surface in plough zone. Large piece of bone, appears calcined, most likely deer	Bone	200 ± 40 BP	310 – 260 BP 220 – 140 BP 30 – 0 BP	1640 – 1700 AD 1720 – 1820 AD 1920 – 1950 AD

NOTES:
[a] Years presented as BP = Radiocarbon Years before Present (i.e., "years ago"), where present is considered to be 1950 A.D.
[b] Calibrated results presented at the 2 sigma (95% probability) range
NA – data not available

Uncalibrated results for the 25 samples reported in Table 5.22 (above) are all younger than 5,000 BP, with most being younger than 3,000 BP. These are consistent with all but three of the conventional radiocarbon dates obtained for the Site C Project by SFU (Spurling 1980b). Sample WSU-1955 from HbRh-66 dated to 5,657 ± 138 BP. This date was obtained from back-channel sediment, not archaeological material, and represented the earliest possible occupation date of the site (Spurling 1980b). Six dates were obtained from HaRk-1, ranging from 1,530 ± 70 BP (WSU-1950) to as old as 5,320 ± 130 BP (WSU-1775) and 5,830 ± 130 BP (WSU-1775) (Spurling 1980b).

SFU researchers also dated HaRk-14, but rejected the resulting date of 590 ± 100 BP (DAL-330). They also obtained a date of 1,910 ± 90 BP from HbRh-8 (Spurling 1980b), similar to the date of 1,840 ± 30 BP (Beta-330011) acquired by the Golder team for this site.

Further details on radiocarbon dates associated with sites in the LAA are provided in Appendix G.

5.2.5.4 Results of Erosion Potential Assessment

A total of 144 archaeological sites were evaluated and ranked using E-PAST. The individual site rankings and E-PAST sheets for each site are presented in Appendix M-1. The sites within the reservoir footprint received scores between 0 and 74. Of the 144 sites evaluated, 56 were classified with Low erosion potential, 35 were classified with Moderate erosion potential and 53 were classified with high erosion potential.

As anticipated, based on the physics driving erosion, sites at higher elevations within and around the reservoir were typically rated with higher erosion potential than sites at lower elevations. Low erosion potential sites at higher elevations are either more resistant to erosion than higher potential sites at the same elevation or more protected from waves and currents. The variation in erosion potential at a given elevation (e.g. elevation 450 m has low, moderate and high erosion potential sites) is related the physical geometry of a given site, the location of the site on the reservoir and the materials present at the surface. The orientation of the long axis of the reservoir relative to local winds means that sites that are situated on terrain subject to winds from the southwest will be subject to more erosion than sites exposed to winds from the northeast based on wind records collected at Ft. St. John Airport over the period 1971-2000. The exposure to winds also influences the observed variation in erosion potential.

5.2.5.5 Analysis of Site Distribution Patterns

This section examines the spatial distribution of Pre-contact period archaeological sites within the LAA and the relationship between site distribution and the biophysical and cultural settings. Although few of the sites produced datable materials, an attempt has also been made to look for possible changes in the site distribution through time. Where other studies have generated information on distribution patterns, the patterns identified in the current study are compared to those found in the broader regional context. This examination of spatial and temporal distribution includes the analysis of site size and content. Finally, the impact of taphonomic processes and sampling and testing methodologies on these patterns is also considered.

The Sample Population

A total of 251 Pre-contact archaeological sites have been identified within the LAA. Of these sites, 22 are previously recorded sites that were not re-examined by the Golder team due to access restrictions at the time of study. Eight additional previously recorded sites had no accurate count of the artifacts found prior to this study and no further artifacts were recovered by the Golder team. Another 10 sites are located in Project components that have not yet been assessed by the field program. These 40 sites are not included in the following analyses since, without relocating the sites and testing to Project standards, the artifact frequencies, site content, site boundaries, and site significance cannot be accurately determined, or at least not to comparable standards. Therefore, the total sample population is 211.

The LAA captures a large area of the lowland plateau that surrounds the Peace River valley. This lowland plateau, also referred to in earlier SFU studies as the upper terrace, is found along the transmission line corridor and in the dam and generating station area. Approximately 24% of the LAA land area is found on the lowland plateau, outside the valley margins and is represented by 46 sites (22% of the sample sites). The remainder of the LAA is in the Peace River valley or its tributary valleys. Most valley terraces are formed by fluvial down-cutting, with the result that the oldest terraces are located higher on the valley slope, while lower terraces are successively younger. Although the lower (and youngest) and intermediate valley terraces are well represented in the LAA, the highest of the intermediate terraces in the valley are only captured within the dam and generating station area where the LAA extends above the reservoir. In areas with some of the highest site concentrations (e.g., on terraces near Cache and Wilder Creeks), the LAA only includes the leading (lowest) edge of the highest valley terraces. As a consequence, valley terraces that are most likely to contain early archaeological sites are largely excluded from the LAA except at the dam and generating station area, based on geological studies at Bear Flat (Cache Creek) that indicate the upper edge of the highest intermediate terrace was down cut by 10,500 BP (Jull and Geertsema 2006), and that artifacts from early periods have only been found on these highest terraces (Spurling 1980b). Since the reservoir pool deepens closer to the dam and generating station, the LAA includes only the lowest terraces at the western end of the reservoir near Hudson's Hope, but captures progressively higher terraces to the east (or downstream).

Site Size

Most of the sites in the LAA are small, as represented by the low number of artifacts recovered from these 211 sites. The results of the testing program indicate that 50 (24%) sites are represented by a single artifact, and a further 63 (30%) sites produced between two and 10 artifacts. A total of 56 (27%) sites have 11 to 100 artifacts. Only 42 (20%) sites contain more than 100 artifacts, 14 (7%) of which produced more than 500 artifacts (Table 5.23). If the information from the 40 sites excluded from this analysis is considered, the artifact frequencies are similar with 57 isolated artifacts, and 184 sites with fewer than 100 artifacts. Determining the areal extent of a site can be problematic, as site boundaries may be inaccurate due to artificial constraints. For example, some sites extend outside the LAA or on to lands where access was not granted and as a consequence, their full boundaries were not confirmed. In these cases, the sites may be larger in area than currently defined if testing were extended beyond the limits of the LAA or into areas that are presently inaccessible. Alternatively, some sites may be smaller than currently thought because boundaries established in earlier studies may be inaccurate and overly-generous (as presented in Provincial Heritage Register). Boundaries are also somewhat arbitrary as isolated artifacts located more than 50 metres apart are considered two separate sites. As a result, a site with two flakes 49 metres apart has a much larger area than a site with two flakes five metres apart, yet the significance and content of the two sites are similar. For these reasons, the following discussion defines site size in terms of number of artifacts rather than site area or artifact density. The site size classes were judgementally selected.

Small Site Distribution

Although no synthesis of site data for northeast B.C. yet exists, most sites in this region appear to be small lithic scatters similar in size to the small sites in the LAA. Interestingly, data from the LAA indicates that the relative proportion of the different size classes is very similar for the plateau and the valley (see Table 5.23). The only notable difference is the absence of large sites from the plateau. This evidence indicates that the factors influencing the size of very small, small, and medium-sized sites are similar in both settings. These smaller sites appear to be well represented in all environmental settings throughout the LAA.

Table 5.23: Site size and distribution in valley and on plateau

Site Size – Class	Artifact Count	Sites in Valley		Sites on Plateau		Total Sites in LAA	
		Count	%	Count	%	Count	%
Very Small	1 to 10	83	50.30	30	65.22	113	53.55
Small	11 to 100	47	28.48	9	19.57	56	26.54
Medium	101 to 500	21	12.72	7	15.22	28	13.27
Large	501+	14	8.488	0	0	14	6.64
TOTAL		**165**	**99.98**	**46**	**100.01**	**211**	**100.00**

Ethnographic and traditional use information support the expectation that most Pre-contact sites in the LAA would be small (see Section 3.2.2). The food resources, such as ungulates, fish, and plants, of the region tend to be widely dispersed and rarely occur in large concentrations. As a consequence, Aboriginal people spent most of the year in small groups composed of individuals from one to several families, often returning to the same

general area each year, but not necessarily the same location. Moreover, much of the technology was organic and would not have preserved in the archaeological record. As a consequence, the expectation is for many small sites covering much of the land, each represented by a small collection of non-organic artifacts.

Given the vegetation cover typically found in the boreal forest, discovery of these sites is heavily dependent on subsurface testing, as employed in this heritage investigation. Unfortunately, given their small size and broad dispersal pattern, this discovery technique is labour intensive and less effective for the discovery of the small sites that dominate the Pre-contact site population than larger sites. Given repeated use of these lands by Aboriginal populations for thousands of years, the expectation should be for a large number of sites scattered throughout the LAA. Some of these occupations might leave very little detectable evidence in the archaeological record, while other occupations would overlap with previous occupations leading to a more pronounced archaeological signature.

Two situations can create conditions where artifacts are exposed on the surface allowing for a better sense of the unseen site distribution: plowing of agriculture fields and reservoir drawdown. In the few instances in the LAA where it has been possible to observe artifacts in plowed fields with no vegetation cover, it is possible to see that smaller sites occur more frequently and over a larger area than suggested by subsurface testing. Unfortunately, even in these situations, much of the cultural material is buried beneath the surface. At Williston Reservoir where drawdown has resulted in large areas where the soil has been removed and the artifacts exposed, the frequency of sites is seen to be much greater and the distribution more wide-spread than had been previously understood (Millennia Research 2010). Even in the Williston Reservoir example it is not always possible to see the entire picture as what little soil is present can still cover artifacts. The results of this work suggest that even relatively intensive testing methods or intervals used on lands identified as having archaeological potential, such as those used for this project or for oil and gas projects throughout the northeast, only reveal a small sample of the small sites in a given area.

Large Site Distribution and Site Complexes

Ethnographic and traditional use information indicates that people may have gathered in large groups for short periods of time (see Section 3.2.2 and 3.2.4). In particular, ethnographic sources suggest that larger groups may have gathered for communal hunting of bison with pounds or caribou with fences (Goddard 1916:214; Jenness 1937:41) or for winter ice fishing at lakes (Goddard 1916:216). The same sources point to certain general localities being used every year. The information, however, does not pinpoint locations in the detail needed to correlate them with known archaeological sites in the LAA. Rather, the traditional use studies repeatedly mention several general localities in the LAA: the Bear Flat – Cache Creek locality, the mouths of the Halfway River, Lynx Creek, Dry Creek, Wilder Creek and Farrell Creek, and the vicinity of Hudson's Hope. Archaeological sites also cluster at the same localities.

Within the LAA, three archaeological site complexes have been identified. Archaeological site complexes are localities with high densities of all sizes of archaeological sites associated with a particular landform or environmental feature (Table 5.24).

The first site complex, Wilder Creek – Jim Rose Prairie, is located on a series of high intermediate terraces on the north side of the Peace River that extends either side of Wilder Creek. The area is known locally as Jim Rose Prairie, a name thought to refer to an area of natural grasslands (Spurling 1980b). At Wilder Creek – Jim Rose Prairie, a total of 20 archaeological sites are found along the leading edge of these terraces comprising an almost continuous, 6.5 kilometres scatter of cultural material. Some of the sites at this locality are thought to extend well back from the terrace edges. However, it was not possible to explore these areas as, for the most part, the LAA only encompasses the front edge of the terraces.

The second complex, Cache Creek – Bear Flat, contains 19 sites and is on a high intermediate terrace on the north side of the Peace River and west of Cache Creek in an area known locally as Bear Flat. Nineteen sites are scattered along the edge of the 5.8 kilometre long terrace. Some sites have also been identified on the terrace behind the edge, but the LAA only includes the front edge of the terrace as part of the Highway 29 realignment.

The third complex, Cache Creek – Watson Slough, contains 39 sites, and is situated immediately below the second complex at a lower elevation surrounding a wetland area known as Watson Slough (Appendix N2 - Photographs 47 and 50). These sites are concentrated either immediately around the slough or on the edge of this intermediate terrace overlooking the Peace River. The 20 sites around the slough extend four kilometres along this old back channel, while the 19 terrace edge sites covers ca. 12 kilometres.

Table 5.24: Archaeological site complexes within the heritage resources LAA

Wilder Creek – Jim Rose Prairie	Cache Creek – Bear Flat	Cache Creek – Watson Slough	
		Near Slough	Near Terrace Edge
HbRg-5	HbRh-10	HbRh-18	HbRh-2
HbRg-6	HbRh-12	HbRh-36	HbRh-6
HbRg-11	HbRh-16	HbRh-38	HbRh-8
HbRg-15	HbRh-33	HbRh-53	HbRh-34
HbRg-17	HbRh-54	HbRh-56	HbRh-37
HbRg-18	HbRh-55	HbRh-65	HbRh-58
HbRg-46	HbRh-57	HbRh-66	HbRh-67
HbRg-47	HbRh-63	HbRh-107	HbRh-104
HbRg-48	HbRh-64	HbRh-112	HbRh-113
HbRg-49	HbRh-68	HbRh-117	HbRh-114
HbRg-50	HbRh-69	HbRh-126	HbRh-115
HbRg-51	HbRh-112	HbRh-128	HbRh-116
HbRg-52	HbRh-143	HbRh-130	HbRh-121
HbRg-53	HbRh-144	HbRh-132	HbRh-122
HbRg-54	HbRh-145	HbRh-133	HbRh-123
HbRg-55	HbRh-146	HbRh-134	HbRh-125
HbRg-56	HbRh-147	HbRh-135	HbRh-126
HbRg-57	HbRh-148	HbRh-136	HbRh-127
HbRg-61	-	HbRh-137	HbRh-131
-	-	HbRh-140	-

Three cultural factors have been identified as contributors to the formation of a large site in the LAA:

- A given location was used by larger groups of people than was the case for most sites
- A given location was used repeatedly though time
- Activities at the site created dense artifact concentrations

It is likely that all three factors coincided to produce these large sites. At 12 sites (Table 5.25) individual shovel tests contained large concentrations of flakes (i.e., >100 artifacts). These artifact concentrations are thought to represent single events where an individual was manufacturing stone tools. These locations do not typically occur in isolation, but are near other large or medium-sized sites and are surrounded by other artifacts within the same site, though in lower concentrations.

Other large sites appear as small, high-density to low-density artifact clusters spread over a large area. Figures 5.28 to 5.30 show the artifact frequencies from each test at three sites with a large area and high artifact counts. GlRj-2 at Boucher Lake is the largest site found on the plateau. With a total of 491 artifacts and an area of 3.29 hectares (0.015 artifacts/m^2), it is typified by a low frequency of artifacts from most tests, with none exceeding 18 artifacts. Two large valley sites exhibit a similar pattern, but with higher artifact frequencies. HaRk-49, on a low intermediate terrace up stream of Farrell Creek, has 689 artifacts and an area of 1.63 hectares (0.042 artifacts/m^2). HbRh-62, on an intermediate terrace at the mouth of the Moberly River, produced 691 artifacts in an area of 1.33 hectares (0.052 artifacts/m^2) (based on data in Alexander 1982). The distribution patterns seen at these three sites are typical of those large sites found elsewhere in the LAA. These sites and others also provide evidence of occupations at different depths. These multi-component sites are thought to represent multiple, sometimes overlapping, occupations by individuals, small groups of people, or perhaps larger groups of people, which could be the result of yearly or seasonal reuse of a location or at sites with evidence of greater time depth, even more sporadic reuse over thousands of years.

Table 5.25: Shovel tests in the LAA with high artifact counts

Site Number	Shovel Test Number	Artifact Count
HaRj-19	SFU 1m x 1 m	635
HbRg-5	15,659	112
	31,627	123
HbRh-144	45,244	917
HbRh-131	29,035	122
HbRh-130	12,332	112
	12,340	112
HbRh-125	18,695	361
HbRh-123	18,707	239
HbRh-122	166	135
HbRh-16	44,914	470
HbRh-36	45,904	103

Site Number	Shovel Test Number	Artifact Count
HbRh-8	45,146	265
	45,147	134
	45,706	297
HbRi-41	45,492	203

The distribution of the large sites and the three site complexes seems to be primarily determined by environmental setting. The sites are most commonly located at the edge of a terrace or slope where the vegetation is typically more open resulting in good views of the surrounding area, more light and heat from the sun, and a dry open camping spot. This setting would also offer a breeze that would provide relief from heat and insects in the summer. Game trails are also common along these terrace edges presenting both easier travel and greater potential for encountering game. Broad intermediate terrace complexes are most common at approximately 30 to 60 metres above the river representing a time period when broadening of the valley predominated over down cutting.

The large sites are also more common in a second setting – in the vicinity of the tributaries, at or near the confluence with the Peace River (Appendix N-2, Photograph 48). These tributaries, in addition to having the largest and most well defined terraces, also provide the largest areas of riparian habitat for game and plant resources in the LAA, and the best fishing in the clear waters of the tributaries and at the mouth during the spring spawning season. In addition to the diversity and quantity of resources offered at these locations, tributaries may have been used as transportation corridors to and from surrounding lakes and uplands.

Lakes and wetlands provide a third setting where large sites commonly occur. Boucher Lake on the transmission line right-of-way is the largest plateau site (Appendix N-2, Photograph 49). It is situated where the lake would have provided fish and waterfowl, the surrounding wetlands contained wetland plants, moose and beaver, and berries grew on the surrounding slopes. Watson Slough is the only large wetland in the valley (Appendix N-2, Photograph 50). The resources at this location would have been similar to those found at Boucher Lake. This unique wetland with its diverse flora and fauna probably accounts for the high concentration of sites above and around the slough. The presence of Charlie Lake, outside the LAA, but near the dam and generating station, would also have attracted Aboriginal people and may, in part, account for the greater concentration of large sites on the north side of the valley at the downstream end of the LAA.

Immediately adjacent to Watson Slough and downstream around Wilder Creek are two locations that were identified as open prairies at contact (Spurling 1980b:103; Mackenzie 1971:163-4). These accounts describe grasslands with large herds of deer, elk, and bison. The ethnographic literature (see Section 3.2.2) suggests that these grasslands were maintained by the local Aboriginal people through the use of fire to periodically reduce the growth of brush and trees. Whether natural or manmade, these grasslands would have attracted large game and likely provide another reason why large sites, and sites in general, are more common near Bear Flat and Jim Rose Prairie.

South Bank versus North Bank

Archaeological sites are more common on the north bank of the Peace River valley than they are on the south bank of the valley (Table 5.26). Of the 165 archaeological sites found in the valley portion of the LAA, 21 (13%) are on the south side and 144 (87%) are on the north side. Sites densities are 0.041 site per hectare on the north side of the valley versus 0.008 site per hectare on the south side or, in other words the site density on the north side is 5 times the density on the south side. Fifty eight percent of the valley lands in the LAA are on the north side. The south side sites include only one large and one medium-sized site, both on intermediate terraces at the mouth of the Moberly River. Very little of the lowland plateau on the north side of the valley is included in the LAA. As a consequence, no meaningful comparison can be made between the difference between north and south side lowland plateau site distribution.

Table 5.26: Site size and distribution north and south side of valley

Site Size / Class	Artifact Count	Sites: South Side of Valley		Sites: North Side of Valley	
		Count	*%*	*Count*	*%*
Very Small	1 to10	10	47.62	73	50.69
Small	11 to 100	8	38.09	39	27.08
Medium	101-500	2	9.52	19	13.19
Large	501+	1	4.76	13	9.03
	TOTAL	21	99.99	144	99.99

This site distribution pattern was noted after the first year (1974) of survey by SFU (Fladmark 1975:109-111). Suspecting that this pattern may have just been a result of selective survey of more easily accessed lands by the survey team, the second year of SFU's judgemental survey (1976) included a more intensive examination of south side localities. However, the results were the same (Spurling, et al. 1976), as were those of the subsequent probabilistic survey of the Site C reservoir (Spurling 1980b).

Several environmental factors probably account for this pattern. Only two large tributaries (Moberly River and Maurice Creek) enter the Peace River along the south bank of the LAA, whereas the north bank has five tributaries of note (Wilder Creek, Cache Creek, Halfway River, Farrell Creek, and Lynx Creek). The archaeological evidence from this study and many others throughout the province indicate that archaeological sites tend to cluster near confluences. This archaeological pattern correlates with the traditional use information that has the most detailed and frequent references to localities at the valley confluences (see above). Lower site frequencies on the south side are, therefore, thought to be related to the lower number of tributaries.

Secondly, fewer and smaller intermediate terraces exist on the south side of the valley. As site densities are higher on the intermediate than the lower terraces, site densities are also lower on the south bank.

It has also been speculated that the north side would be preferred because of greater exposure to sunlight during the winter months. The assumption is that both the human population and the animals that they hunted would have preferred the warmer setting.

Possibly related to the greater exposure, the north side of the valley also has more grasslands and low shrub communities. These grasslands are mentioned in the earliest historic records of the valley, where large herds of moose, elk, and bison (Mackenzie 1971:163-4) are reported in the open prairies (thought to refer to either Bear Flat or Jim Rose Prairie). The gentler terrace slopes and old slide areas also exhibit areas of open grassland or parkland.

Due to less solar heat and increased frost penetration, the south side is also subject to more slides (Spurling 1980b:17). These slides resulted in more hummocky terrain on the terraces and produced a less desirable camping location than the flat, stable terraces on the south side. Also, the slides may have removed or buried sites, reducing the likelihood of discovery of sites on this side of the valley.

Islands, Floodplains, and Lower Terraces

No Pre-contact sites have been found on the islands or active floodplains (less than 3.5 m above the river level) in the river valley. The primary reason for this lack of sites is probably erosion. Archaeological material on the floodplain would be removed by fluctuating water levels, especially during the spring floods. Similarly, the islands are migrating downstream due to headward erosion and tailward deposition with the exception of the bedrock islands that occur upstream of the Gates (11 kilometres downstream from Hudson's Hope). As a result, these islands do not typically contain sediments from the Pre-contact period. Moreover, as the river has been slowly down cutting through time, these areas would have also been exposed relatively recently and are therefore likely to have been available for use only for only a short period of the Pre-contact period.

Although, game preferentially uses the islands and floodplains in some seasons, vegetation cover and cultural practices are thought to discourage their use by the Aboriginal population. The floodplain is used by moose in winter and during calving, the floodplain and islands by deer during summer fawning and the post-fawning period, and bears favour floodplains in spring and summer. Where the land surface is stable, the vegetation growth in these areas is dominated by cottonwood and wild rose that creates a largely impassable tangle of brush and deadfall. Therefore, these areas would have been less attractive to the Aboriginal population than other parts of the valley. The Blueberry River First Nation traditional land use study (Kennedy 2011) also states that at least some of the forested islands of the Peace River form a sacred refuge for animals, especially moose and deer during calving or rearing. Therefore, subsistence hunting is culturally restricted in these locations.

The lower terraces (3.5 to 9 m above the river) also contain few sites. Only 21 sites have been found on these lower terraces, almost exclusively at the upstream end of the LAA between Farrell Creek and Maurice Creek where these lower terraces are more common. Radiocarbon dating of archaeological deposits on a lower terrace downstream from Farrell Creek (HaRk-23) indicates that terraces 4.5 metres above the river were available for occupation by approximately 2,300 years ago. These lower terraces at the western end of the LAA may have been used more prehistorically than those at the eastern end of the LAA because there are fewer well-defined, higher terraces near the river at the western end. The incised valley typically ranges from 1.5 to 2.5 kilometres in width, but it is widest at the western end with maximum width of 5 kilometres at Lynx Creek and minimum of 0.6 kilometres at the Moberly River confluence. As a result the higher terrace tends to be further back from the river at the western end.

Lowland Plateau

Archaeological sites along the lowland plateau portion of the transmission line corridor are concentrated near the dam and generating station and at the west end near the Moberly River and Boucher Lake. Near the dam and generating station the plateau topography consists of a low continuous slope with micro-topographic relief in the form of shallow mounds and, where drainage is impeded, swampy hollows. The western end of the transmission line corridor is located in the uplands with an undulating, rounded topography (Appendix N-2, Photograph 51). The low-lying areas of muskeg along the central portions of the transmission line with little topographic relief contain few sites. As has been found on other parts of the plateau, the sites in these environmental settings are located most typically on the top of dry knolls and ridges.

Overall, the site density in the valley is 1.5 times the density on the plateau, with 0.019 site per hectare, on the plateau and 0.028 site per hectare in the valley. This evidence indicates that the valley was used more intensively than the plateau, though the difference is not as great as seen between different sides of the valley. Another means of measuring intensity of use is the average number of artifacts per site. In this case, the average site size is 3.8 time greater in the valley than on the plateau (148 versus 39 artifacts per site) in spite of the fact that sites on the plateau could date to any time in the last 10,700 years, and potentially have a much longer history of use than sites in the valley.

Stratified Sites

Archaeological sites with deeply buried archaeological materials (i.e., multiple occupation levels more than 50 cm below the surface) were only located at two locations with the LAA: Farrell Creek Site (HaRk-1) and three sites (HaRk-23, HaRk-16, and HaRk-46) located close to each other on a lower terrace, downstream from Farrell Creek. The former is the result of aeolian deposition on a cliff-top dune, the later probably a result of fluvial depositional events. Other sites contain evidence of multiple occupations, but within only 40 to 80 centimetres of deposits. At the latter sites, it is not always possible to see changes in soil colour that could help isolate or distinguish between occupation layers, unlike the Farrell Creek area sites where darker cultural deposits alternate with thick fluvial or aeolian deposits.

Taphonomic processes may be affecting the distribution of cultural materials at these sites. For example, at HaRk-1 the occupation surface would have been subject to both deflation and deposition of aeolian soils thought to explain why some of the “features” identified at the site were difficult to interpret, and occupation events hard to isolate (Spurling 1980b). At HbRf-62 obsidian artifacts thought to represent a single event were found at depths of 15 to 34 centimeters below the surface suggesting vertical movement of the artifacts by natural processes (Alexander 1982).

Temporal Changes in Site Distribution

Too few sites can be dated by either radiocarbon dating or relative dating of temporally diagnostic artifact types to detect any detailed changes in the site distribution patterns through time. Radiocarbon dates are available for 20 sites in the LAA (Section 5.2.5.3), with dates range from ca. 150 to 5,800 radiocarbon years. Diagnostic artifacts have been recovered from 13 additional sites. The little evidence that is available suggests that the most frequently used locations continue to be used throughout the Pre-contact period in the valley (as noted at the Farrell Creek site, HaRk-1). However, given that the valley is down-cutting through time, the lower the terrace elevation, the less time the terrace surface would have been available for occupation. Therefore, early sites tend to occur only on the highest terraces. Radiocarbon dating of archaeological and geological deposits in

the valley indicate that the highest portions of the intermediate terraces (approximately 80 metres above the river) were available for occupation by 10,500 BP and terraces only 4.5 metres above the river were available for occupation by 2,300 BP. Another date for the valley includes non-cultural sediments from the base of a sediment core from Watson Slough dated to 5657±138 (Spurling 1980b:34).

As an example, microblades have been recovered from only six archaeological sites in the LAA; two near Watson Slough (HbRh-66 and HbRh-122); two on the intermediate terraces near the mouth of the Moberly River (HbRf-62 and HbRf-93), and two on the transmission line (HaRf-32 near the dam and generating station and HaRj-32 near the Moberly River at the western end of the line). This small sample makes it difficult to discern any pattern in the distribution of microblade sites other than to suggest that since microblades have not been recovered from younger landforms such as the lowest terraces, these sites likely pre-date 2,300 BP.

Temporal Changes in a Regional Context

All uncalibrated radiocarbon dates in the LAA obtained between 2010 and 2012 are younger than 5,500 BP, with most pre-dating 3,000 BP (Table 5.27). These results are consistent with all but three dates previously obtained for an earlier variation of the Site C Project by SFU (Spurling 1980b). WSU-1955 from a non-cultural backchannel sediment at Watson Slough is dated to 5,657 ± 138 and is thought to represent the earliest possible occupation date for HbRh-66, a small microblade site (Spurling 1980b). Six dates were obtained from the multicomponent Farrell Creek site (HaRk-1). The most recent date from this site is 1,530 ± 70 (WSU-1950), but it also contained charcoal that dated from 5,320 ± 130 BP (WSU-1775) and 5830 ± 130 (WSU-1775; Spurling 1980b). SFU researchers also obtained a date of 1,910 ± 90 from HbRh-8, but rejected a date of 590 ± 100 (DAL-330) obtained from HaRk-14 (Spurling 1980b).

The oldest date reported in British Columbia's Peace area comes from Charlie Lake Cave near Fort St. John (HbRf-39; Driver 1988). This date (SFU-454) is 10,770 ± 120 BP, though calibrating this date places its range from 12,630 to 12,869 BP (68% range; CalPal 2012). Excepting dates which came back strictly modern and could not be calibrated, the youngest date previously obtained from the region was from nearby HbRf-83 (Beta-246033) at just 100 ± 40 BP. Calibrating the date from HbRf-83 places it as young as modern, and as old as 270 years BP (Archer 2006). Given this date was inconsistent with points recovered from the same level, that may be as old as 4,000 – 6,000 BP, the site deposits were interpreted as disturbed and the date as out-of-context (Archer 2006). One other site in the British Columbia Peace area, Gutah Creek (HkRe-1) produced a date of 1280 ± 40 (Beta-190980) on charred material from an occupation layer at the site (Heritage North 2006).

In British Columbia and Alberta, more than 160 radiocarbon dates have been reported in the Peace area, including those collected by the Golder team (Spurling 1980b; Driver 1988; Heritage North 2006; Morlan and Betts 2012). They include dates from strictly paleontological contexts (n = 20), the coal from HkRe-1 (Heritage North 2006), and the backchannel sediment from HbRh-66 (Spurling 1980b). Excluding these dates and those that returned modern dates, 133 dates are available in the region (see Table 5.27), including 22 collected by the Golder team.

Nearly one-third of the dates (29%; n = 39) from the Peace area are older than 5,000 years BP uncalibrated, although none of these were obtained by the Golder team. The 5,000 BP or older dates came from just five sites: HbRf-39 (n = 16) and HaRk-1 (n = 2) in British Columbia, and FlQs-30 (n = 1), HcQh-6 (n = 7), and GhQt-4 (n = 14) in Alberta.

Saskatoon Mountain in Alberta (GhQt-4) was slightly younger than Charlie Lake Cave (its oldest date was 9,380 ± 360 BP [AECV-1474C]), but also had a broad range of dates. The youngest of its 16 dates was 1,680 ± 140 BP (AECV-1095C). These two sites have the largest number of radiocarbon dates in the region, with a combined 40 of the total 133 dates.

Table 5.27: Radiocarbon dates from the Peace River area (British Columbia and Alberta)

Date Range (uncalibrated) in years BP	Number of Dates	Percentage of Total for Peace River (B.C. and Alberta)	Sites (excluding those dated by Golder Team)	Project Dates Only	Percentage of Total Collected by Golder team	Sites Dated by Golder Team
0-999	15	11.3	FlQs-30, GiQa-3, GjPx-6, GlQp-6, HaPl-1, HaRk-14, HaRk-14, HbRf-83	4	18.2	HaRj-23, HbRh-12, HbRh-131, HbRi-10
1,000-1,999	34	25.6	FlQs-30, GaQs-1, GdQp-1, GhQt-4, GjPx-6, GlQp-6, HaRk-1, HbRf-39, HbRh-8, HkRe-1, IgPc-2	7	31.8	HaRk-16, HaRk-23, HaRk-46, HbRg-50, HbRh-8
2,000-2,999	20	15.0	FlQs-30, GlQa-3, GlQp-6, HaRk-1, HbRf-39, HcQh-6, IgPc-2	8	36.4	HaRj-14, HaRk-16, HaRk-23, HaRk-38, HbRh-36, HbRh-55, HbRh-131
3000-3,999	7	5.3	GiRi-1, HbRf-62, HcQh-6	1	4.5	GlRj-2
4000-4,999	18	13.5	FlQs-30, GaQs-1, GhQt-4, GlQp-6, HaRk-1, HbRf-39, HcQh-6	2	9.1	HbRg-47, HbRi-6
5,000-5,999	10	7.5	FlQs-30, GhQt-4, HaRk-1, HcQh-6	0	-	-
6,000-6,999	2	1.5	GhQt-4, HbRf-39	0	-	-
7,000-7,999	10	7.5	GhQt-4, HbRf-39, HcQh-6	0	-	-
8,000-8,999	4	3.0	GhQt-4, HbRf-39	0	-	-
9,000-9,999	6	4.5	GhQt-4, HbRf-39	0	-	-
10,000-10,999	7	5.3	HbRf-39	0	-	-
Total	133	100	-	22	100	-

Figure 5.31 plots the relative probability of calibrated radiocarbon dates in the LAA and compares these plots to those from the British Columbia and Alberta region. Like the 22 new dates from the LAA, previously collected dates from British Columbia's Peace region, demonstrate that many sites are aged 5,500 years or younger with a fall-off in radiocarbon dates between 1,000 to 300 years BP. However, calibrated dates collected prior to this project (n = 37) are skewed to the early Paleoindian period, due to the large number of dates from Charlie Lake Cave. When the 22 new dates are combined with the larger dataset, including Alberta's Peace region dates (n = 133), the early dates assume less importance. The data still show an increase in dates between 5,500 and 4,800 BP, a decline between 4,800 and 4,000 BP then a more gradual increase, followed by another decline between 1,200 and 300 BP. In general, dated sites are more common after 5,500 BP.

Data from dated archaeological and geological deposits in the Peace region indicate that spikes in the frequency of forest fires through time do not seem to correlate with fluctuations in the human population. The frequency of dated archaeological sites in the Peace region of Alberta and British Columbia (including those in the LAA) are shown in Figure 5.32. The frequency of these sites through time can be used as a measure of the regional human population assuming that the frequency of dated sites is similar to that for the undated sites and that the number of sites increases with an increase in population. Radiocarbon dating of palaeosols and buried charcoal horizons on a fluvial fan at Bear Flat, within the LAA, provide evidence for forest fires, with higher fire frequencies at 10,000 to 9,000 cal BP, 8,200 to 7,500 cal BP, 6,000 to 5,500 cal BP, and 2,800 to 2,200 cal BP (Jull and Geertsema 2006:435). When these spikes in forest fire frequencies are plotted against the frequency of dated sites (see Figure 5.32.) it can be seen that the fire and site frequencies seem to fluctuate independently of each other, though at least in some cases, the site frequencies are declining when the fire frequencies are increasing. This evidence suggests the possibility that forest fires either directly impacted the human population by having a negative impact on the habitat and resources that the population depended on, or are an indirect measure of other changes to climate and vegetation that impacted these resources, such as drier climatic conditions.

Figure 5.32 also indicates that the frequency of sites in the Peace region increases after approximately 5,500 BP. This increase in population corresponds with a change to wetter and more moderate climatic conditions and a generally more stable environment. White and Mathewes (1981) suggest that the formation of permanent ponds and wetlands around this time represents a key shift in the character of the Alberta Plateau. Prior to this change, the many small lakes and ponds and associated well-drained areas may have been suitable places for human habitation, but as the lakes became wetlands and ultimately bogs, settlement patterns may have changed. The climate and vegetation changes would have likely affected ungulate and bird habitats as well. It may be possible that an increase in permanent wetlands allowed for an increase in the local moose population and in certain bird species in the LAA. A gradual increase in the human population can also be seen with the establishment of modern vegetation.

Other climatic changes may also account for declines in the human population indicated in Figure 5.32. Cooler temperatures between approximately 1,360 BP and 150 BP, known as the Little Ice Age correspond to declines in the site frequency in Figure 5.32. The White River Ash fall at 1,147 cal BP (Section 3.1.5.4) may also have impacted the local climate by lowering temperatures and contributed to local population declines. These cooler conditions would have resulted in harsher, longer winters in the LAA.

Site Content and Site Distribution

It is difficult to discern any site distribution patterns based on the cultural material found at the sites in the LAA. The low number (533) and frequency (3.6%) of formed tools in the collections limits discussions to impressions rather than statistical analysis of site content. Using the example above, microblades have been found at only six sites. This small sample could be interpreted as a preference for the use of microblades in wetland settings (four sites), but it is more an impression than a certainty. The artifact collection is, for the most part dominated by black chert flakes that occur throughout all environmental settings. The ratio of formed and utilized tools to debitage at sites with more than 10 artifacts, typically varies from about 1% to 8% for all settings. A few exceptions are found in all settings. Of the 50 (24%) sites that are represented by a single artifact, 10 (20%) consist of a formed tool. These single artifact sites, with or without tools, are dispersed through all settings, with higher frequencies of single artifact sites more common in areas with higher densities of large and moderate sized sites. The heavy dependence on the use of snares and other perishable technology as suggested by ethnographic and traditional use information may account for the low frequency of lithics at many sites throughout the Peace region.

Pre-contact cultural features are rare in the LAA. Only one possible feature was located during testing for this Project–a hearth identified on the basis of a concentration of charcoal in association with lithic artifacts. Fire altered rock is rarely encountered in a Pre-contact archaeological content and none is reported from the testing program. The difficulty of recognizing features is discussed in SFU's report on excavation at the Farrell Creek site (Spurling 1980b). Although the site contained concentrations of artifacts and bones in association with changes in soil colour, the patterning could not be easily interpreted.

Pre-contact Period Human Remains

Although ethnographic and traditional use information suggests that Pre-contact period human remains could exist in the LAA, no evidence was found for Pre-contact burial features in the LAA and none of the 2,309 bones and bone fragments recovered in the 2011 and 2012 field seasons were identified as human. Nor did any of the previous studies in the LAA (e.g., Alexander 1982; Archer 2008a, 2008b; Fladmark 1975, 1979, 1981; Golder 2009a, 2009b, 2009c, 2009d, 2010a, 2011b; Fladmark 1975, 1979, 1981; Spurling 1978, 1980a, 1980b; Spurling, et al. 1976) identify Pre-contact human remains. However, much of the bone assemblage (99%) is fragmented, unidentifiable to species, and in some cases poorly preserved making it difficult to distinguish human from other large mammal remains without the aid of expert forensic methods including DNA or thin-sectioning to seek subtle microscopic differences (e.g., Crescimanno and Stout 2012; Hillier and Bell 2007; Mulhern and Ubelaker 2001; Saulsman, et al. 2010). Many of the bones are also burnt or calcined and distinguishing between human and animal bone is particularly difficult in the case of burnt bones. Bones which are cremated–burnt with the flesh still attached–may demonstrate different burning patterns than those which have been butchered first (Ubelaker 1989) and warping or transverse cracking patterns may also indicate cremation (Ubelaker 1989; Whyte 2001), but even then it is not possible to distinguish animal from human cremations (Whyte 2001).

Other evidence indicates the bones recovered from these sites are likely not human. At several of the sites (e.g., GlRj-2, HaRg-38, HaRk-38, HaRk-46, HaRk-50, HbRf-115, HbRg-47, HbRg-50, HbRh-131) the bones show evidence of butchering (e.g., cut marks), an activity not reported for any traditional human burial practices in the region. At most sites, the bone fragments are associated with the detritus of stone tool manufacture indicative of campsites and animal butchering sites rather than burials. Moreover, no objects were found in association with these bones that may be interpreted as grave goods, that is, possessions buried with their owner at death. The fragmentary remains are also scattered rather than gathered in one location as would be expected of a below-ground burial of a body or wrapped or boxed cremated remains.

The scarcity of human remains in the region (Section 3.2.1.2) and the lack of evidence for burials in the LAA may, in part, be the result of environmental factors and the scarcity and difficulty of locating such sites. Although below-ground burials are described for the region during the historic period, most ethnographic sources (Section 3.2.1.5) suggest that above-ground burials were more typical. These above-ground burials, located on the surface, on platforms, or in trees, were more susceptible to destruction through weathering and animal and human disturbance (Wilson 2004) and are unlikely to be preserved in the archaeological record. Although few locational details are available, the descriptions of traditional burial practices suggest that burial sites typically consisted of a single individual, buried either in a collapsed shelter at a campsite that was then at least temporarily abandoned or some distance away from a village or campsites, on a river bank, hillside, or hilltop (Section 3.2.3.2). These practices would have typically resulted in small isolated sites that would be difficult to locate archaeologically.

Bison Pounds

While bison are reported to have been particularly abundant at the time of contact with Europeans (Mackenzie 1970), and an important component of the Aboriginal diet at this time (see Goddard 1916; Ridington 1981), recovery of identifiable bison remains is limited to one bone from site HaRk-38. SFU Site C field work in the LAA also did not encounter bison bones in the Pre-contact period sites. Both cultural practices and taphonomic factors may account for this discrepancy between the ethnographic and archaeological record.

Spurling (1978) and Fladmark (1975) have suggested the importance of bison is, in fact, under-represented in the ethnographic record, and that periods of starvation mentioned in Goddard's work (1916) were exacerbated by the post-contact depletion of bison herds. For example, at Fort d'Epinette, historic overhunting and extirpation of large bison herds is suggested as the cause of a reduction in bison frequencies in the upper (later) archaeological levels (Fladmark 1975).

Despite the reported importance of bison, they are rare in the archaeological record, and even where present, the number of identifiable elements is dwarfed by elk (e.g., Spurling 1980b; Hamilton 1987). From the Golder team's field program, two elk bones were identified (one each from HaRk-49 and HbRh-131), compared to the single bison bone (HaRk-38). While these numbers are too small for significant comparison, they are consistent with previous research, although the examples are limited mostly to post-contact sites. At Fort d'Epinette, the ratio is nearly seven to one (917 elk, 132 bison) (Spurling 1980b). At Rocky Mountain Fort, the ratio is three to one, despite the journal records which suggest more bison were hunted than elk (e.g., Burley and Hamilton 1991). Rather than representing the actual contribution of these two species to diet, Burley and Hamilton (1991) suggest these numbers can be attributed to the more intense processing of bison bone for grease, including for pemmican production, and that bison did contribute more to the fur traders' diet than elk.

This differential processing may extend into the Pre-contact period. Unidentifiable fragments of mammal bone were commonly recovered from archaeological sites in the LAA, and represent 99% of specimens recovered. At least some of these fragments are attributed to large ungulate, artiodactyl, or bovids, and could potentially represent bison. Unidentified mammal and ungulate bones are also prolific in sites that have been previously studied, including and Pre-contact sites such as HaRk-1 (Spurling 1980b) and HbRg-4, the latter of which were suspected to be bison. In other words, bison may be present in the Pre-contact faunal assemblage but only as small fragments that cannot be identified to species by standard visual examination.

Ethnographic and traditional use information supports the possibility of large bison kill sites in the LAA. These accounts suggest that either pounds or buffalo jumps were employed in the region. While Goddard reports that pound, not jumps, were used, jumps have been reported by residents on the Beatton River north of Fort St. John

and near Charlie Lake (Fladmark 1975) and traditional use data provided to the Golder team tells of the last buffalo jump near Watson Slough before the bison population plummeted (Volume 3 Economic and Land and Resource Use Effects Assessment, Appendix B First Nations Community Baseline Reports). These latter reports may actually be confusing jumps with pounds, since despite having their corrals constructed on flat ground, pounds were often located at the base of hills or precipices (Verbicky-Todd 1984). Unlike jumps, the drop from a pound would not be steep enough to incapacitate the animal (Verbicky-Todd 1984). Pounds may also incorporate steep embankments as part of the corral, where animals are driven against base of steep embankment and dispatched, rather than over its precipice. Pounds may have been the preferred bison hunting technique as individual hunting of bison was not condoned, according to Goddard (1916). Nevertheless, the large bison kills found in the prairies of Alberta may not exist in the Peace region as the wood bison populations in the Peace region would not have had the large open prairies that supported the large herds of the Alberta prairies.

Site Distribution and Sampling Strategies

The goal of the archaeological field program was to describe the location and characterize the nature of Pre-contact heritage resources within the LAA, such that potential Project effects on those resources could be assessed. Probabilistic sampling for an earlier variation of the Site C Project by SFU in the 1970s and 1980s provided a representative (unbiased) sample of sites from lands that include almost the entire valley portion of the LAA. Based on the results of this sampling, as well as judgemental survey and testing of these areas, Millennia Research developed an archaeological predictive model that captured within the modeled high potential areas, those lands most likely to contain Pre-contact sites in the LAA. The results of many impact assessments throughout the plateau portion of the Peace region were used to develop the model and identify high potential areas for the plateau portion of the LAA. These high potential areas represent those lands in the LAA that were most heavily used in the past and as such contain some of the largest sites and highest densities of sites and artifacts. In other words, the sample of sites from the intensive and systematic testing of the high potential lands favoured discovery of these types of sites. Small sites in areas with low site densities are not as well represented, but would have been probabilistically sampled by SFU and the model testing in 2010, and judgementally tested and inspected by pedestrian surveys by both SFU and the Golder team. Although the sample of sites from the LAA analysed above favours those sites in the modeled high potential areas, it does include a sample, some collected during probabilistic surveys, of sites throughout the LAA.

The intension of the Golder field program was not to find as many sites as possible in the LAA nor to collect an unbiased sample, but to discover as many high significance sites as possible. Site significance is defined on the basis of criteria as established in Appendix D of the *British Columbia Archaeological Impact Assessment Guidelines* (BC Archaeology Branch 1998). In the LAA, these high significance Pre-contact sites contain one or more of the following: a variety of artifact types, multiple raw materials, stratified deposits with multiple occupations, or faunal remains. Most of these sites, in order to have these characteristics, are also large or medium sized sites. For the purposes of this assessment, these more complex sites have been labelled “Class I” sites (see Figure 5.33).

It is difficult to estimate how many sites may have been missed in the sampling program because, as information from Williston indicates, we do not fully understand the nature (e.g., site size, density, and distribution) of the background population of sites. Statistical tests, like those suggested for use by the BC Archaeology Branch, produce wide ranging results depending on the assumptions made about this background population. These tests predict that when testing in areas with small sites or sites comprised of single artifacts, and using small shovel tests at 12 metre intervals, there is little certainty that all sites have been found. On the other hand, at

localities with large sites and high artifact densities, this testing method would rarely miss sites. Spurling (1980b) attempted to estimate the number of sites they anticipated in the 1970s version of the Site C Project area based on the use of the probabilistic sampling scheme used for that program (see Table 5.28). The results of the SFU study are not directly comparable to those from the Golder team's field program, as the size and shape of the study area, the testing interval, and shovel test sizes are different for each. However, these site estimates suggest that sites found during the Project are at the lower end of expectations suggested by the SFU data and that many more sites remain undiscovered in the LAA, though based on statistical tests, few large sites (often the most significant sites) have been missed.

Table 5.28: Site estimates based on SFU probabilistic survey

SFU Sample Stratum	Equivalent LAA Stratum	SFU Survey Results		SFU Site Estimates		Project Results	
		Total Survey Area (hectares)	% Surveyed	Site Estimate	Range	Area	Sample Sites found by Project
North Upper	North Side Lowland Plateau	2,925	10	341 ± 50	191 - 391	540	12
North Intermediate	North Side Intermediate Terraces	2,575	20	216 ± 74	142 - 290	3,495	144
North Lower	North Side Lower Terraces	2,150	20	96 ± 53	43 - 149		
South Lower	South Side Intermediate Terraces	1,800	15	66 ± 57	9 -123	2,504	21
South Intermediate	South Side Lower Terraces	1,425	14	22 ± 26	0 - 48		
South Upper	South Side Lowland Plateau	3,250	5	22 ± 43	0 - 65	1,857	34

6.0 HISTORICAL RESOURCES

The historical resources program included documentary research, a historical resources overview assessment, stakeholder interviews, and field investigations. Historical heritage sites are defined as any structure, site or thing that is of historical or architectural significance. Historical sites and locations in British Columbia are primarily attributable to post-contact Euro-Canadian settlement and land use, but also include habitations and other evidence left by Aboriginal peoples in that time period.

Section 6.1 describes the approach and methods for the historical resources program. Section 6.2 summarizes the results of the program. Appendix J contains detailed descriptions for the historical sites identified within the LAA.

6.1 Approach and Methods

This section describes the approach and methods used for each component of the historical resources program, including documentary research methods, stakeholder interview methods, field inventory and assessment methods, data collection, recording, and analysis.

6.1.1 Historical Documentary Research

A review of historical background data pertinent to the LAA was undertaken, with a focus on Euro-Canadian history. There is an extensive body of primary historical research and documentary information that exists for the LAA (e.g., Burley, et al. 1996; Kyllo 2003; Spurling 1978) and the broader Peace region. Arcas' (2009:61) gap analysis study identified the following historical heritage data gaps in the LAA:

- Uncertainty whether the inventory of recorded historical sites (i.e., those sites in the Provincial Heritage Register) represents the complete range and number of potentially extant historical sites
- Incomplete knowledge of the age, origin, context, size, content, and function of recorded historical sites (except Rocky Mountain Fort)
- Incomplete knowledge and recording of the location of trails, old roads, portages, and river fords

To address these data gaps, Arcas (2009:61) recommended "additional documentary research, including review of archival literature, land records, published historical accounts, and other documentary sources." The review of historical information examined these sources as available, focusing on the data gaps as identified above. In addition, the review sought to update current records for previously identified historical sites, and to identify additional historical sites in the literature. A list of key search terms was developed to focus the research on identified data gaps, specific historical site types, and locations of potential historical interest. Primary and secondary sources were identified and reviewed for content relating to historical sites in, or near, the LAA.

Particular attention during the review was paid to the following themes: transportation methods and routes, aspects of settlement and interactions with the environment, developing economies (e.g., extraction and production, trade and commerce, communication, technology, and engineering), and building social and

community life. These broad themes and sub-themes are representative of those in Parks Canada's (2009) *National Historic Sites of Canada System Plan.* Similar to the archaeological resource requirements, the historical resources study area was extended to those project components in which development plans are at a preliminary stage, to gain an impression of the historical resource potential in these lands at an overview level and to identify potential future regulatory requirements.

Reviewed material included accessible and relevant archival literature, past land records, published historical accounts, historical aerial photographs, historical land surveyor field books, and British Columbia Archaeological Site Inventory Forms. The review included an examination of information concerning local and regional history as it relates to historical sites in the Peace region, including written, cartographic, and photographic documents from published and unpublished sources. Cartographic materials were examined for historical site references, relevant mapped features, notations and field observations, and to aid in identifying areas requiring more intensive documentary research or field visits. Written materials were examined for content relevant to the list of key terms and to supplement information derived from cartographic sources.

Dominion Land Surveyors' field books and plans of select Peace River Block Sections in the LAA, on file with the British Columbia Surveyor General in Victoria, were examined (Brenot 1912a, 1912b, 1913a, 1913b, 1914a, 1914b, 1915; McCusker 1930). The Dominion Land Surveyors' field books are the source for compiled plans of Peace River District townships within the LAA (Department of the Interior 1915, 1916a, 1916b, 1916c, 1916d, 1916e, 1916f, 1916g, 1916h, 1917, 1918, 1920) and the published compilation describing surveyed townships in the Peace River District (Department of the Interior 1916h). These handwritten Dominion Land Surveyors' field books or plans often include information on the land applicant (i.e., pre-emptor) and inhabitants (i.e., squatters) encountered during the in-field survey; observed features such as pack trails (or subsequently, 'wagon roads'), cabins, fords, or boat landings; and landmarks, terrain, and natural conditions (Figure 6.3 and 6.4). This information was compiled, and surveyed locations of pack trails were digitized in advance of the field component of the historical resources program.

Historical aerial photographs for the LAA and surrounding land were obtained from the University of British Columbia, Geographical Information Centre. Aerial photographs from 1945, 1953, 1953, 1954, 1967, 1969, 1977, 1981, 1986, 1996, and 1997 were reviewed for features of historical interest and the results are summarized in Appendix L. The referenced map sheets (1 to 16) in Appendix L correspond to those areas identified in Figure 6.5.

Simon Fraser University (SFU) archival records contain information regarding work undertaken by SFU researchers in the 1970s and 1980s in the LAA. During the review of SFU archival records, data specific to historical resources were obtained on loan and copied. These copies of original field notes and maps were used to assist with field investigations.

At the time of the original SFU research, site maps were typically created from then-current aerial photographs. Prior the current field assessments, the Golder team examined and compared the original SFU site maps, 1970s aerial photographs as well as other historical aerial photographs dating as far back as the 1930s, and SFU field notes that describe site location and observed features to the current location of the historic site, as recorded in the Provincial Heritage Register. Some discrepancies regarding the previously recorded site locations or documented information were noted, and the field crew sought to clarify these discrepancies.

Valuable information about many of the previously recorded historical sites was obtained from the SFU photographic collection. These photographs serve as a documentary record of the historical sites and features, many of which are no longer intact. Very few photographs of the historical sites were reproduced in the SFU reports from the 1970s and 1980s (e.g., Fladmark 1975; Spurling, et al. 1976); a selection of the SFU photographs has been reproduced in this report (Appendix N-3).

Sources of information for the review include local histories, regional histories, community heritage site inventories and registers, the Provincial Heritage Register, and archival materials. Sources included:

- Local government records (City of Fort St. John, District of Hudson's Hope, City of Vancouver)
- Provincial government records (BC Archaeology Branch, B.C. Archives, B.C. Heritage Branch, Peace River Regional District, Simon Fraser University, B.C. Surveyor General, University of British Columbia)
- Federal government records (Transport Canada 1973 to 1975, 1975, 1976 to 1983, 1977, 1979, 1983; Transportation Safety Board of Canada 2010)
- Corporate libraries (AMEC, BC Hydro, Golder Associates)

Online resources (Calverley 2010; Mills 2010; Peace River Museum 2010; Leonard 2012) and private resources (Northern Maritime Research 2002) were also used. The results of the historical documentary research are summarized in Section 6.2.1.

6.1.2 Historical Resources Overview Assessment of Selected Areas

Project components for which development plans were not adequately advanced to allow for a thorough historical resources field assessment were subject to a historical resources overview assessment. The assessment considered background data on historical resources in these development areas including any previous historical field studies, as well as pertinent information provided by stakeholders and long-term residents. Similar to the archaeological overview, the components include as yet undefined construction activity areas near the dam site (2,040 ha), Wuthrich Quarry (18 ha), West Pine Quarry (104 ha), Portage Mountain Quarry (148 ha), Del Rio Pit (135 ha), and Area E (80 ha). The overview does not include some access roads, unless captured under other project components (e.g., original dam site footprint), a transmission line tie-in at Peace Canyon Dam Generating Station, and a potential aggregate source located within the reservoir but above the inundation zone.

6.1.3 Stakeholder Interviews

Interviews with stakeholders were conducted to provide an understanding of what historical resources are valued within the LAA and why they are important. As well, participants were asked to identify sites, places, buildings, or other resources of historical or heritage importance in the LAA that reflect their values and ideas of heritage.

Stakeholders comprised: (1) groups and organizations that have a potential interest in the historical sites and heritage values of the LAA such as local and regional historical societies, museums, an archives committee, and

a committee dedicated to documenting locations of local cemeteries, and (2) property owners or lessees in the LAA, as well as individuals whose families were former residents of the LAA. Generally, telephone interviews were conducted with representatives of the historical groups and organizations, whereas in-person interviews were held with property owners, lessees, and individuals. Separate and unique heritage questionnaires were prepared for the historical groups and organizations, as well as for the long-established residents (identified as "Stakeholder Questionnaire" and "Property Owners/Lessees Interview" respectively in Appendix K).

For the first series of stakeholder interviews, the Golder team contacted representatives of local and regional historical societies, museums, an archives committee, and a committee dedicated to documenting locations of local cemeteries to explain the purpose of this historical study and to determine interest in proceeding with a telephone interview. In cases where representatives preferred to provide a written response, the Golder team forwarded the written "Stakeholder Questionnaire" to the representatives (Appendix K). Providing responses to each question was at the discretion of each representative.

The second series of stakeholder interviews was conducted with long-established residents of the LAA or their relatives. The Golder team requested in-person interviews with local residents who previously provided information on known heritage sites (including palaeontological, archaeological, and historical sites) directly to BC Hydro representatives or to the Golder team. In addition, in-person interviews were requested with property owners or lessees who responded to a 2011 questionnaire administered by BC Hydro that included questions related to heritage and who requested that a heritage specialist follow up. At the beginning of the in-person interviews with long-established residents, participants were provided with the "Property Owners/Lessees Interview" heritage resources questionnaire (Appendix K). This questionnaire included a project status update, an overview of the heritage resources effects assessment, a privacy statement, and pertinent questions regarding heritage sites. In addition, orthographic and topographic maps which included the LAA, as well as more detailed locational maps relevant to each interviewee were provided. Responding to some or all questions, or identifying locations of historical sites on the maps was at the discretion of each participant. The in-person interviews were conducted by the Golder team, and a BC Hydro representative was in attendance as well.

In both series of interviews, local and regional stakeholders were asked to identify words or themes that describe the historical identity of the Peace River valley, specifically in, and adjacent to, the LAA. This information was sought because historical themes express movements, events, or ideas that have led to the breadth of historical resources visible in a region. Identifying historical themes in a region enables a community to articulate its unique heritage values and identify historical resources based on these values. The words, ideas, and comments identify historical sites that are valued by the stakeholders, and explain why the local community considers these locations important. The information also reflects local or regional stakeholder values and ideas of heritage, which, in conjunction with the BC Archaeology Branch Checklist of Criteria for Post-Contact Site Evaluation (*British Columbia Archaeological Impact Assessment Guidelines* [1998], Appendix E), contributes to the assessment of significance of historical sites within the LAA. In addition, stakeholders' words, ideas, and comments connect with the broad themes and sub-themes which were the focus of the historical documentary research review, specifically transportation methods and routes, aspects of settlement and interactions with the environment, developing economies (e.g., extraction and production, trade and commerce, communication, technology, and engineering), and building social and community life (Parks Canada 2009).

Results of the interviews with historical groups and organizations, and with local residents or their relatives were compiled and are summarized in Section 6.2.2 of this report following convention in social sciences.

6.1.4 Field Survey Methods

6.1.4.1 Objectives and Scope

During the historical heritage resource field assessment, historical sites located within the LAA were identified, recorded, and evaluated (Figure 6.1). Work undertaken in the inventory phase was guided by background research undertaken by the Golder team, data obtained during reconnaissance surveys and the archaeological field program, and information provided by stakeholders. The historical field investigations focused on visiting, documenting, and assessing recorded historical heritage sites as well as documenting and assessing newly identified sites. If background research, reconnaissance surveys, the archaeological field program, or information provided by stakeholders did not identify historical resources or indicate potential for historical resources in a project component, then a field inventory was not conducted by the historical crew. The transmission line and 85th Avenue industrial lands were not surveyed by the historical crew since there was no information to suggest that this project component contained historical resources. A select number of locations were examined by the historical crew adjacent to the LAA to confirm the location and assess the extent and condition of the sites. Additional field assessment remains outstanding for proposed access roads, quarries and excavated construction materials areas, a transmission line tie-in at Peace Canyon Dam Generating Station, areas inaccessible due to high water conditions, and some private land parcels for which access is currently restricted. These locations will be addressed in a manner consistent with the current heritage assessment as development plans are finalized or access is obtained, prior to land-altering activities in those areas.

6.1.4.2 Survey Methods

Historical field survey methods generally followed those described in British Columbia *Heritage Conservation Act* Permit 2010-0378, including (1) systematic survey; (2) adaptive testing; and (3) judgemental survey (see Section 5.1.5). The areas to be surveyed were determined in accordance with the strategy outlined above.

Field crews were equipped with LiDAR hillshade imagery, orthophoto maps, and other suitable maps, and located areas to be surveyed using programed Garmin GPS 60CSx receivers.

6.1.4.3 Site Recording Methods

Historical heritage sites were photographed and mapped by chain and compass, or GPS, or both. The location of each site was plotted on orthophoto maps or LiDAR hillshade maps.

Subsurface (shovel) test locations, field observations, and test results (positive or negative) were recorded using GPS. Detailed notes included, but were not limited to, the following:

- Terrain and setting description
- Location description
- Attributes of surface finds and features
- Subsurface test logs (identification number, location, depth, results, observed matrices)
- Photograph logs

All historical heritage sites identified were recorded following recognized industry recording standards (e.g., Gotthardt and Thomas 2007; Government of Alberta 2008; Parks Canada 2010; National Park Service 2011; Washington State 2011). Only historical heritage sites that are protected under the British Columbia *Heritage Conservation Act* were entered into the Provincial Heritage Register.

6.1.4.4 Site Boundaries

Sites boundaries were established using judgemental and adaptive subsurface testing, mapping of surface features, and historical sources. Historical site boundaries were defined on the basis of observed or arbitrary limits, or a combination thereof. Observed boundaries are those determined on the basis of the extent of historical heritage materials or features, as observed on the ground surface, in exposures, through subsurface testing, or a combination thereof. Arbitrary boundaries are those which reflect artificial or administrative boundaries, such as property lines, the presence of existing impacts or developments, or where sites extend beyond the LAA.

For previously recorded sites, information from existing site records, reports and, where available, archival (SFU) field notes were used to confirm site locations and characteristics. Input from local residents also helped confirm site locations and characteristics.

6.1.4.5 Data Recording and Collection

Surface and subsurface historical materials identified in the field were recorded as to location, type, and material. Historical materials were collected at the discretion of the Crew Leader. All collected material was processed and analyzed, and entered into an artifact catalogue. Information that was recorded includes provenience, material, object type, minimum object count, dimensions, date range if known, and additional comments such as shape, colour, and decoration. Standard industry practice was used to analyze historical materials recovered or documented during the field programs, drawing upon reference collections as required. Sources used to aid identification and object age include Adams (2002), Miller (2000), and Rock (2000).

6.1.4.6 Assessment of Erosion Potential

Similar to archaeological resources, the Erosion Potential Assessment Scoring Technique was used to quantify the degree to which specific historical sites within the LAA may potentially be impacted by natural and human erosion. As with archaeological sites, erosion of historical sites is related to the inundation of the site by water stored in the reservoir. Although inundation by itself is not sufficient to result in erosion, moving water resulting from waves and currents has the potential to erode sites that were not exposed to these conditions prior to inundation. Once a site is subject to moving water, the velocity of the water and the ability of surface materials to resist erosion determine to some extent whether a site can be expected to experience erosion. Additionally, historical sites around the perimeter of the reservoir may also be affected by reservoir erosion even if they lie outside the actual reservoir footprint. An example of this would be a site at the top of a steep slope, the toe of which is subject to shoreline erosion when the reservoir is inundated.

The E-PAST tool was applied to historical sites located within and adjacent to the reservoir, to a maximum elevation of 466 masl, which corresponds to the peak reservoir level during passage of the probable maximum flood.

6.1.4.7 Historical Resources Evaluation Methods

The significance of historical sites, including those protected under the *Heritage Conservation Act*, was evaluated by the application of the Checklist of Criteria for Post-Contact Site Evaluation in Appendix E of the *British Columbia Archaeological Impact Assessment Guidelines* (BC Archaeology Branch 1998). The checklist consists of five significance categories (scientific, historic, public, ethnic, and economic) as well as separate categories for integrity and condition, and "other." For the evaluation of historical sites identified within the LAA, criteria defined under "other" were considered under scientific and public categories. Significance under each category was evaluated as either "yes" (the site is significant) or "low" (the site is of low significance). Integrity and condition were evaluated as "good" or "poor." In addition, a key component in determining the significance of historical sites was the heritage values identified by stakeholders. This information was then used to derive a Class I, Class II, or Class III rating for sites as a basic framework for mitigation (see Volume 4 Section 32.2.2.3 Historical Resources).

6.2 Historical Resources Results

The results of the historical resource program, specifically the documentary research, historical resources overview assessment, stakeholder interviews, and field investigations are provided in the sections that follow.

6.2.1 Historical Documentary Research Results

Sections 6.2.1.1 to 6.2.1.1.4 below describe the results of the documentary research regarding historical sites in the LAA as well as in the broader Peace region, with a focus on the data gaps identified in Section 6.1. The sections are organized around the themes of developing economies and settlement. A summary of historical sites recorded at the provincial and national level follows.

6.2.1.1 Settlement of the Peace River Landscape

The Arcas gap analysis stated a need to "identify and record the location of heritage trails, old roads, portages, and fords through archival, oral history and field reconnaissance to reconstruct historical transportation routes" (Arcas 2009:49). To address this recommendation, the review focused on transportation methods and routes as discussed in the literature and indicated on historical maps. Other important historical themes that are considered in this review, as described in the sections below, are aspects of settlement and interactions with the environment, developing economies (e.g., extraction and production, trade and commerce, communication, technology, and engineering), and building social and community life. These broad themes and sub-themes are representative of those in Parks Canada's (2009) National Historic Sites of Canada System Plan.

6.2.1.1.1 Developing Economies – Transportation

The following section provides a summary of historical transportation methods and routes in the LAA as well as the broader Peace region. This includes a discussion on vessel types, navigation and landings, aircraft, trails and roads, and river crossings.

Prior to the creation of formal roads capable of bearing wheeled transport, the Peace River and other navigable waterways in the region were the principal source of transportation. As a result, seasonal camps, trading posts, and eventually permanent settlements were located along both river and stream banks. There were no surveyed trails west of the Smoky River, which flows into the Peace River northeast of Grande Prairie, until an all-Canadian access route to the Yukon (the "Moody" trail) was surveyed through the Peace River region from Edmonton in 1898 (Galois and Ray 1993). As transportation technology developed, direct effects on the landscape became apparent. "In some places the trails became well-marked highways often being depressed two feet below the surface. Many of these old trails are still faintly visible on hills or in coulees leading down to watercourses, especially to good crossing places" (Calverley 1999i).

Camps and, later, homesteads and settlements, also occurred where Pre-contact trails came together on the riverbank, and these locations often became the future landings for ferries such as at Rocky Mountain Portage House near Hudson's Hope (Calverley 1999i). While no docks were built for the steamboat trade, the landscape around their landings was transformed by cutting great swathes of trees to supply their fireboxes with cordwood. Where trails had previously depended on fords or ferries to cross rivers and streams, with the development of roads, these were generally replaced with bridges, and the original locations of these crossings either built over or bypassed entirely.

The development of overland transport to the upper Peace River region came in stages. The first access by railroad to the area occurred in 1916, when the first train on the Central Canada Line, the Edmonton Dunvegan and British Columbia Railway (ED&BC) ran into what was then the Village of Peace River Crossing, Alberta (Atlas of Alberta Railways 2005). It was to this railhead that the first load of coal mined in the upper Peace River region was shipped down the Peace River by barge in 1923 (District of Hudson's Hope 2006). In 1931, when the Northern Alberta Railways reached Dawson Creek, a wagon road was built into the Peace River region, south of Fort St. John. From here, freight was carried west in long, narrow river scows and boats with gas engines (Harrington 1963). The motor boats (gas or diesel) were able to operate with small crews and did not require cutting hundreds of cords of wood each year to operate. The wagon road to Dawson Creek, followed by improvements to other roads, and eventually the completion of the Alaska Highway in 1942, meant that commercial transport by water on the Peace River became restricted to heavy loads shipped by scow to and from the Town of Peace River, Alberta. Following a survey of northern railway lands (Government of the Province of British Columbia, et al. 1929, 1930), and six years after the last commercial freight was shipped on the river, the Pacific Great Eastern Railway finally arrived at Fort St. John in 1958 (Barman 1991:281).

6.2.1.1.1.1 Vessels Propelled with Paddle and Oar

The earliest form of transportation on the Peace River was probably the raft. Rafts continued to be used extensively in the historic period. Athapaskan-speaking peoples in the Peace, Mackenzie, and Yukon River watersheds generally employed rafts for crossing rivers and tending fishing nets (e.g., Black 1955:12, 17, 48, 89-90, 193, 197), and also used skin-covered frame boats for downstream voyages with a large load

(e.g., Sherwood 2004:133) as well as cottonwood dugouts. West of the Rockies, the Beaver and Sekani people used canoes made of bark and propelled by paddles for fishing and hunting, as well as for family travel between camp sites and for long-distance trade (Jennings 2002a:22). Two styles of bark canoe were employed. The "kayak-type" canoe was a small hunting canoe, distinctive in shape and construction (Adney and Chapelle 1983:154-173; Finch and Gardner 2002:67). The "narrow-bottom canoe" could range between 5.0 m and 6.5 m (16 ft. and 22 ft.) in length and was used for family travel and trade; it was similar in shape and construction details to the Algonquin-Ojibwa canoes (Finch and Gardner 2002:69). Canoe-building methods from the east were introduced by the arrival of Cree people involved in the fur trade by the late 1700s (Adney and Chapelle 1983:155). Most of the canoes brought to the region by the North West Company (NWC) would have been of moderate size by fur trade canoe standards, typically 5.8 m to 6.4 m (3 or 3½ fathoms, or 19 to 21 ft.) in length, and carrying about 25 pieces (41 kg each) (Adney and Chapelle 1983:138, 141, 144). Canoes are shallow drafted and capable of navigating the tributary rivers and streams of the LAA. For example, the 1879-80 map near the headwaters of the Pine River notes that "Indians ascend the river to this point in small canoes in spring" (Geological Survey of Canada 1879-80).

The fur traders were looking for a practical, water-level route through the Rockies to the Pacific Ocean. While the Peace is the only river to cross the Continental Divide, it proved to be located too far north to serve as a suitable transportation route. The Hudson's Bay Company (HBC) found that it was actually easier to send ships around Cape Horn, South America to reach New Caledonia (i.e., British Columbia; Morse 1969:101). With its 20 km (12 mi.) length, the Rocky Mountain portage at Hudson's Hope was the same length as the Methye portage (or "Portage La Loche") in Saskatchewan, which was commonly recognized as the longest portage in the regular fur trade. The Rocky Mountain portage was further described by Simon Fraser as "amazing bad" (in Ramsey and Murray 1969). As a result, access to the European markets for fur and trade goods was entirely eastward looking, with canoes or boats traversing the continent to ports along Hudson Bay or the St. Lawrence River. Based on journal writings (see Fladmark 1975:47-51), Golder has estimated that canoes paddling upstream on the last leg of the journey through the LAA between Rocky Mountain Fort and Rocky Mountain Portage House would stop to make overnight camps at intervals of approximately 11,500 m ± 700 m. This would be equivalent to five camps within the LAA, likely situated in the general vicinity of the following locations:

- Near the Peace River-Wilder Creek confluence, Jim Rose Prairie, island, or opposite shore
- Near the Peace River-Cache Creek confluence
- Near the Peace River-Halfway River confluence
- At a point between the Peace River – Halfway River confluence and the Peace River – Farrell Creek (also known as Red River) confluence, probably on the opposite (i.e., south) shore
- Near the Peace River – Lynx Creek confluence, near "the Gates"

On the downstream journey, boats or canoes were sometimes tied together to drift with the current overnight, camping only to "make tea" and, as such, possibly camping at different intervals (Johnson 2006:77). Leitch (1950:107) reports rafting the Peace River starting at Johnson Creek, west of Hudson's Hope, with a first stop for lunch at Halfway River, and reaching Fort St. John at 9 p.m. The downstream journey by raft to Fort Dunvegan, Alberta, took a total of 45 hours of travel, covering approximately 435 km (270 mi.) (Leitch 1950:107).

The Methye portage spanned the divide between watersheds of the Hudson Bay to the south and east and the Arctic-flowing waters within what the fur traders called the Mackenzie and Athabasca Districts. After 1821 when the HBC merged with the NWC, canoes were generally replaced in the fur trade by York boats, employing large oars, or sweeps, and sometimes sails. The York boats carried twice the load with the same number of men as the *canot du nord* ("north canoe") (Johnson 2006:165). By 1823, the HBC was employing York boats carrying 50 pieces as far as Fort Chipewyan (Johnson 2006:31). Freight transport was the responsibility of the Athabasca Brigade from the Clearwater River onto the Athabasca River, then turning up the Peace River from Fort Chipewyan to Vermilion Chutes. Although still hundreds of kilometres away, these rapids at Fort Vermilion were the last barrier to navigation on the Peace River before entering the LAA. After portaging or lining through, the Brigade boats could travel on to Fort Dunvegan, and to Fort St. John and eventually to Rocky Mountain portage or Hudson's Hope after trading posts reopened there in the last half of the 19th Century (Johnson 2006:77). This navigable stretch of water, known as the "upper Peace River," between the Vermillion Chutes and the Peace River Canyon, including the LAA, measures over 900 km (550 mi.) in length.

Following 1886, when the Methye portage was abandoned, sturgeon-nosed boats and Athabasca scows were introduced on the Athabasca River (Johnson 2006:81). Above the Peace River Canyon, flat-bottomed scows were used, as were cottonwood dugout canoes and bateau-style boats powered with outboards when these motors were introduced. It is not clear to what extent these other boat types may have been used within the LAA. Journal records have not been examined, but York boats travelling primarily under oar-power would have made roughly the same speed as loaded canoes (Johnson 2006:46) and continued to use the same camp sites. The last York boats for commercial service were built in the 1920s (Johnson 2006:157).

While watercraft introduced by the fur trade were largely used by settlers to move goods, they also had other uses. Klondikers ascended the Peace River in York boats in 1899, and in the same year York boats were used by travelling government parties conducting Treaty No. 8 negotiations (Johnson 2006:38,153). Large bark canoes continued to be used in the region, for example by the Geological Survey of Canada in the 1920s (Jennings 2002b:41).

Small watercraft were numerous, but the loss of one is rarely recorded. Watercraft typically enter the archaeological record as a result of accident or, more usually, abandonment near camps or ferry locations. Although fragile, the organic remains of small vessels may survive indefinitely if covered with river sediments.

6.2.1.1.1.2 Vessels Propelled with Steam and Gas

The era of steam navigation on the upper Peace River lasted from 1903 to 1930. Although steam had been introduced on the Athabasca River in 1887, to service the upper Peace River, a steam vessel would have to be winched over the Vermilion Chutes or built above them. It was the Catholic Church that launched the first steamer, the *St. Charles*, for use on the upper Peace River in 1903, from the St. Augustine Mission near the town of Peace River (Crossing), Alberta. The HBC quickly asserted dominance over transport in the region by launching the 272 ton sternwheeler *Peace River* in 1905. As the main form of transportation and communication, steamboats became an integral part of most activities in the LAA, playing a major role in the development of the economy and a key part in the shaping of the communities in the region until 1930 (Peace River Museum 2010). The final commercial freight run on the upper Peace River was made in 1952 by the *Watson Lake*, a steel-hulled vessel owned by the HBC (Clare 1998a).

Table 6.1 summarizes historical information about the 17 largest vessels used on the upper Peace River between 1903 and 1952. Data sources for Table 6.1 include Mills (2010), Northern Maritime Research (2002), and Peace River Museum (2010). Notable is the fact that all but five of them were built on the upper Peace River. While their machinery was always imported and was sometimes unsuitable, the hulls themselves were built locally and adapted for local conditions. Seven of these vessels were built in the five-year period from 1912 to 1916 when settlers in large numbers were entering the Peace District. Among these vessels was the *D.A. Thomas* which, when launched, was the "largest steamboat from the Great Lakes to the Pacific" (Hansen 1977). Almost all of the vessels built on the upper Peace River were built at, or near, the town of Peace River. Almost equidistant between Hudson's Hope and Fort Vermilion, the town of Peace River was the centre of upper Peace River navigation in every sense. Most of the boats were built there, primarily at the West Peace Shipyards, and typically they were hauled out to winter there. It may be observed that the location with the largest number of reported vessel losses or abandonments is also the town of Peace River (Table 6.1).

Table 6.1: Larger vessels operating on the upper Peace River, 1903 to 1952

Vessel Name	Vessel Type	First Year of Operation on Peace River	Location Built, Builder	Vessel Size (Length, Beam, and Gross Tons)	Owner	Cause of Loss	Year
St. Charles	Steam screw propeller	1903	St Augustine Mission, near Peace River, AB	18 m by 3.5 m (60 ft. by 12 ft.), 29 tons	1. Catholic Church 2. Ford & Lawrence	Wrecked by ice in Peace River, AB	1915
Peace River	Steam sternwheeler	1905	Fort Vermilion, by A. Watson	33.5 m by 7.5 m (110 ft. by 24 ft.), 272 tons	HBC	Abandoned, at Fort Vermilion?	1916
Messenger	Steam screw tug	1905	Built in 1897, Kenora ON, winched through Chutes in 1905	10 m by 2 m (33 ft. by 7 ft.), 5 tons	HBC	Abandoned or broken up at Peace River, AB	1914
Grenfell	Steam sternwheeler	1912	Peace River, AB, by C. Magar	139 tons	Peace River Trading and Land Company (Diamond P.)	Stranded on bar and destroyed by fire 24 km (15 mi.) above (west of) Fort St. John	1914 (Sept)
Beaver – Pine Pass	Gas motor screw tug	1915	Prudence Crossing, AB	22.5 m by 4.5 m (74 ft. by 15 ft.), 42 tons	Smoky and Peace River Company	Burned at Peace River, AB	1920

Vessel Name	Vessel Type	First Year of Operation on Peace River	Location Built, Builder	Vessel Size (Length, Beam, and Gross Tons)	Owner	Cause of Loss	Year
Athabasca River	Steam sternwheeler	1915	Built in 1912 in Athabasca Landing, AB, winched over the Chutes in winter	42 m by 9 m (136 ft. by 28 ft.), 341 tons	HBC	Rebuilt as scow, beached as warehouse in Peace River, AB in 1919, later burnt	1930
Northland Call – Hudson's Hope	Steam sternwheeler	1915	Peace River, AB	30 m by 5.5 m (100 ft. by 18 ft.), 192 tons	1. Peace River Navigation Company 2. Lamson Hubbard Canadian Company	Beached and abandoned, Peace River AB	1920
Peace River Boy	Motor screw propeller	1915	Prudence Crossing, AB	21 m by 4.5 m (69 ft. by 14 ft.), 16 tons	C. Smith	Broken up at Peace River, AB	1920
D.A. Thomas	Steam sternwheeler	1916	Peace River by G. Askew	49 m by 11 m (162 ft. by 37 ft.), 1114 tons	1. Peace River Development Corporation 3. Lamson Hubbard 4. Alberta and Arctic Transportation Company 3. HBC	Brought over the Chutes to Fort Fitzgerald, converted to hulk for grain	1930
Lady Mackworth	Gas screw tug	1916	Peace River, AB	NA	Peace River Development Corporation	NA	NA
Weenusk	Motor (diesel) screw tug	1921	Vancouver	18 m by 3.5 m (60 ft. by 11 ft.), 29 tons	HBC	Retired Mackenzie River	1940
Beulah ***Baby Beulah*** ***Beulah 3***	Motor screw tugs with scows	1920s	Peace River, AB	NA	Beulah Boat Company	Some sold out of area	NA
Weenusk II	Gas screw tug	1940	NA	NA	HBC	Moved off Peace River	1951
Alcan	Gas sternwheeler	1941	NA	NA	U.S. Army	Moved off Peace River	1946
Watson Lake	Steel motor screw tug	1951	Peace River, AB	NA	HBC	Moved off Peace River	1952

NOTE:
NA – data not available

6.2.1.1.1.3 Steamboat Heritage

When they operated, steamers were an important form of communication, with each arrival leading to the stoppage of all other activities in the community (Hansen 1977). The community attachment to this legacy has persisted. The *D.A. Thomas* holds pride of place among steamboats because of its size and advanced technology for its time. At the end of its working life after 1930, the *D.A. Thomas* was run over the Chutes down to Fort Fitzgerald, Alberta, where it was laid up as a granary hulk. Ten years later the hull was burned. In the late 1980s, a group of dedicated citizens found the original blueprints and sought to locate and recover any machinery that may have survived with plans to build a replica. The 14 ton wheel shaft and one boiler were returned to the Fort St. John area in 1986, and are now in the Peace River Museum and Archives collection along with the blueprints (Calverley 1999d).

It appears that the only possibility for archaeological remains of a steamboat or other large vessel in the LAA is the *Grenfell* (Table 6.1). The recent recording of five Klondike-era steamboat wrecks on the Yukon River demonstrates the potential for the survival of substantial steamboat hull remains in shallow waters subject to heavy winter freezing and strong flow (Pollack 2008). Fires typically leave the lower hull and machinery intact. LiDAR images of the LAA reveal subsurface river bed features with surprising clarity. The *Grenfell* was supposedly lost 24 km (15 mi.) upstream of Fort St. John. In the LiDAR images there are three anomalous images located between 17.5 km and 25.5 km upstream of Old Fort that are compatible with the lower hull remains or machinery of a steamboat the size of the *Grenfell.* If extant, the wreck of the *Grenfell* is protected under the British Columbia *Heritage Conservation Act*, and possibly eligible for nomination as a shipwreck of national historical significance due to its technical and representative characteristics (Historic Sites and Monuments Board of Canada 2000).

6.2.1.1.1.4 Navigation and Landings

The season of navigation on the upper Peace River lasted from approximately the first of May until the end of September. During this time, three to four round trips between Vermilion Chutes and the town of Fort St. John or Hudson's Hope would be made by each vessel per season, each trip lasting approximately one month (Peace River Museum 2010). The vessels did not always go as far as Hudson's Hope because the river through the LAA was shallow and not always navigable by larger vessels. Pilots were hired to help navigate through shifting channels, and sometimes vessels were winched over bars (Peace River Museum 2010). Groundings, including some that resulted in salvageable sinkings, were frequent (Calverley 1999; Ramsey and Murray 1969). However, only the *Grenfell* suffered a grounding that resulted in a total loss. Its loss was ultimately due to a fire that is supposed to have started in the galley, that broke after the vessel ran aground (Peace River Museum 2010).

Like the York boats and canoes, powered vessels navigating on the Peace River stopped for the night. For smaller vessels, this meant that passengers were disembarked to make camp (Peace River Museum 2010). The calculated rate for travelling upstream from the towns of Peace River to Fort St. John is just over 64 km per day (40 mi. per day). At this rate, a boat could almost pass completely through the LAA from Fort St. John to Hudson's Hope in one day. However, in addition to Fort St. John and Hudson's Hope, it is known that steamboats stopped at possibly three other locations within, or near, the LAA. These five landing locations are described below:

- Fort St John: Boat landing locations in, or near, the LAA have varied over time including landings adjacent to the HBC post (Old Fort), at Taylor where Aboriginal trails were said to converge at the riverbank (Calverley 1999i), and eventually, in the 1920s, at Thorsen's Landing in Grandhaven where the access up the bank was easier (Scheck 1973:111)
- Immediately east of the Peace River – Wilder Creek confluence: Known as Reed's Landing, where a trading post was located in 1918, and where a number of trails appear to converge (Canada Department of Lands 1936; Robinson 1973a:409)
- Immediately east of the Peace River – Halfway River confluence: Near the Cadenhead homestead (Cadenhead's Landing), "there is a good landing in Section 28 and both the Hudson Bay Co. and Diamond P steamers call here every trip" (Brenot 1913a; Department of the Interior 1916h:251)
- A speculative location, somewhere between the Peace River – Lynx Creek confluence and the Peace River – Farrell Creek confluence: Location based on spacing, generally matched with the Wilder Creek landing and the number of settlers in the locality
- Hudson's Hope: Along the north bank of the river, the boat landing place "below Jack Pallon's home was long used by steamers" (Harrington 1963)

6.2.1.1.1.5 Aircraft

Aircraft were important to the development of the Canadian North, providing access in summer and winter to areas not served year-round by overland routes. Single-engine bush planes, fitted with wheels, skis, or floats, have been active in the LAA since the 1920s, and continue to provide service along with helicopters. Northern British Columbia was "opened" to mineral exploration and settlement in the 1930s by bush pilots like Grant McConachie and Russ Baker (Barman 1991:263). The first "airport" in the area was a float plane base known as Powell's Landing established on Charlie Lake after 1934 (Kelsey 1963). While construction of the Alaska Highway for the movement of wartime materials opened up the region to road travel, hundreds if not thousands of aircraft also flew through the LAA and broader Peace region as part of the lend-lease program to Russia between 1941 and 1945.

There is no database or other accessible primary source for aircraft crashes that occurred prior to 1970. A review of one secondary source indicates that no aircraft were lost in the LAA during the Second World War (Victoria Times Colonist 2006). A review of Transport Canada and Transportation Safety Board of Canada records provides a partial list of aircraft incidents between the years 1970 and 1983 (Canada Ministry of Transport 1971-1972; Transport Canada 1973-1975; Transport Canada 1976-1983) and between 1990 and 2008 (Transportation Safety Board of Canada 2010). During these periods, there were at least 41 incidents involving crashed aircraft in the vicinity of the LAA. Most of these incidents (n = 17) occurred at an airport or airstrip and involved "substantial" or "minor" damage to the aircraft, suggesting that aircraft or aircraft wreckage was removed or salvaged after the accident. In seven of the incidents, the aircraft were destroyed. Only one of these was located in water. On June 20, 1971, near Fort St. John, a Bell 206A helicopter "collided with telephone wires while flying at low level in a deep river gorge and crashed in to the river" killing all three people aboard (Canada Ministry of Transport 1971:18). The coordinates provided in the synopsis indicate the crash occurred in the Beatton River, and if any wreckage remains it is therefore outside of the LAA. The other six crashes that led

to the destruction of the aircraft were located as follows: 1) a single-engine aircraft 32 km (20 mi.) north-northeast of Pink Mountain (Transport Canada 1975:17); 2) a crop sprayer about 2.5 km northwest of Dawson Creek (Transport Canada 1977:49); 3) and 4), two single-engine aircraft located 14 and 16 km (9 and 10 mi.) northeast of Beatton River (Transport Canada 1979:59-60); 5), a helicopter 24 km (15 mi.) north of Fort St. John (Transport Canada 1979:49), and 6) a single-engine float plane on a hillside adjacent to Charlie Lake (Transport Canada 1983:55). None of these reported locations are within the LAA.

6.2.1.1.1.6 Trails and Roads

Several overland transportation routes throughout the LAA are shown on historical maps and referenced in the reviewed literature. The type of route (e.g., pack trail, wagon trail, wagon road) was often described, but the description was routinely inconsistent, due to its subjective nature. For the purposes of this study, these overland routes are captured under the term “trails.” While emphasis is placed on reporting major discrepancies between maps of trail locations, it is important to note that minor discrepancies were also noted between historical trails and modern roads, which are often located on the same general route. These discrepancies can be explained by the observation that historical trails often meandered to avoid minor terrain impediments, while modern roads more often follow straight routes across the landscape.

6.2.1.1.1.7 Rocky Mountain Portage at Hudson’s Hope

The trail associated with the Rocky Mountain portage is shown on each of the reviewed historical maps of that area, first appearing on the 1879-80 map (Geological Survey of Canada 1879-80; Canada Department of Lands 1912; Department of the Interior 1916f, 1919, 1928; Canada Department of Lands 1922, 1928, 1931, 1936, 1945; Office of the Surveyor General 1922; Canada Department of Lands and Forests 1963; B.C. Geographic Division 1963; Canada Department of Lands, Forests, and Water Resources 1965). This trail commences in the LAA at Hudson’s Hope and the proceeds due west beyond the LAA. The location of this trail is relatively consistent throughout all maps reviewed. A 2001 photograph west of Hudson’s Hope illustrates that remnants of the Rocky Mountain portage trail, first documented by Mackenzie in 1793, are still visible (Kyllo 2003:70).

This trail is also referenced in several of the reviewed historical sources (Akrigg and Akrigg 1975; Calverley 1999p, 1999q; Department of the Interior 1916h; Gordon 1963; Harrington 1963; Howarth 1917; Kyllo 2003; Leitch 1950; Pike 1963). Key quotations and excerpts that may be relevant to the Rocky Mountain portage include the following:

- **1793 –** “From a camp on Farrell Creek, [Alexander] Mackenzie first glimpsed the far-off mountains, the same shining mountains that the *coureurs de bois* had sighted from the southern prairies many years earlier. On May 18 they reached the portal. Almost everyone knows that he missed the ancient Indian portage road, and spent two days trying to track the canoe up the rapids. On May 22 at daybreak they started to cut their own portage overland across the mountain. They reached the head of the canyon where they found the old war-trail that they should have taken.” (Caverley 1999t)
- **1879 –** “The trail leads up to a broad terrace which skirts the base of a hill known as the Buffalo's Head. The hill takes this name from a favourite camping ground close by, which has, for many years, been marked by the head of the last buffalo that was shot in this part of the Peace District.” (Gordon 1963:138)

- **1879 –** "...the twelve mile Portage to the foot of the Canyon." (Gordon 1963:138)
- **1903 –** "While exploring the canyon, Campbell and Leitch were sure that they had identified the spot on the north bank where Sir Alexander Mackenzie and his party had left the canyon and started overland across Rocky Mountain Portage. It is just above the first rapids as one enters the canyon from Hudson's Hope." (Sage, in Leitch 1950:85)
- **1916 –** "In Section 23 a pack-trail is crossed known as the 'Rocky Mountain Portage', connecting Hudson's Hope with Cust's House at the head of 'Peace River Canyon'." (Department of the Interior 1916h:261)
- **1916 –** "Access is also possible by canoe from Fort George in British Columbia by going north to the headwaters of Peace River and then down that stream, except for a portage of twelve miles at Peace River Canyon which neither small nor large craft can navigate. This portage, known as the Rocky Mountain portage, passes through Sections 23, 24 and 13." (Department of the Interior 1916h: 261)
- **1917 –** In discussing a trip from Jim Beattie's cabin to Hudson's Hope through the Peace River Canyon "The way first led upward for many hundred feet. . . . As I hurried along, I had a consciousness that I was following a historical high-way. For a century this has been the path followed by Indians and trappers on their way to and from the mountains. Mackenzie had trodden it, and McLeod and Finlay and Butler and Pike and other celebrities whose names are associated with the 'great lone land' of the far north. To the left rose a high rocky hill that earlier travelers, familiar with buffalo, called 'the Bull's Head,' and the resemblance was easy to be seen. On some later maps the name is given to a mountain across the Peace, but this is due to a surveyor's mistake." (Howarth 1917:267)
- **1917 –** "In old days the portage began only a little distance above the canyon. . . ." (Howarth 1917: 265)
- **1917 –** "A fair trail, twelve miles in length on the north side of the river, leads to the navigable water above the canyon, while the stream runs a circuitous course of probably thirty miles." (Pike 1963:156)
- **1913-1949 –** "He [James Beattie] cut the first wagon road around the present portage, from Hudson's Hope to 20 mile." (Calverley 1999q)
- **1950 –** "The portage trail 'of the Canyon of the Mountain of Rocks' once trod by moccasined feet, is today a truck road. It winds steeply up out of Hudson's Hope, past the old graveyard and the new cemetery." (Harrington 1963)

6.2.1.1.1.8 Trail between Hudson's Hope and Moberly Lake

A trail south of Hudson's Hope to the west edge of Moberly Lake is shown on the majority of the reviewed historical maps of that area, first appearing on the 1879-80 map (Geological Survey of Canada 1879-80; Canada Department of Lands 1912, 1922, 1928, 1931, 1936, 1945; Department of the Interior 1916f, 1919, 1928; Office of the Surveyor General 1922; Canada Department of Mines and Technical Surveys 1950; Canada Department of Lands and Forests 1963; B.C. Geographic Division 1963; Canada Department of Lands, Forests, and Water Resources 1965). The northern portion of the trail, immediately south of Hudson's Hope, is located within the LAA and trends to the south outside the LAA before crossing the transmission line. The trail location is relatively consistent throughout the earlier maps, with a discrepancy appearing on the 1945 map in which the trail spurs east in the general vicinity of the transmission line right-of-way. This spur is not shown on subsequent maps of the area. The trail is also shown as being located further to the west on one of the 1963 maps (Canada Department of Lands and Forests 1963), closer to the current location of Highway 29, while still being shown as

crossing the Peace River at Hudson's Hope. It is not until the 1965 map that the trail is shown as the current location of Highway 29, including crossing the Peace River downstream of Hudson's Hope.

This trail is referenced in four of the reviewed historical sources (Calverley 1999i, 1999l; Department of the Interior 1916h; Leitch 1950). Key quotations and excerpts that are relevant to this trail include the following:

- **1903 –** "In our [haste] we came upon the old Du Pont trail of 1896 and followed it over the hill. . . ." (Leitch 1950:101) [This trail had been followed by the geological expedition of which Davies had been a member some years previously. It was a pack-trail leading south from Peace River.]
- **1903 –** "I got energetic and climbed the hill to Prairie above in hopes of shooting some grouse and finding an overland trail to Davies Creek, but were unsuccessful, although we found a trail leading to the Moberly Lakes." (Leitch 1950:97)
- **1916 –** "This fractional township [Hudson's Hope] may be reached by. . .a pack-trail south of the [Peace] river branching at Moberly Lake from the Pine Pass pack-trail." (Department of the Interior 1916h:258)
- **1916 –** "Hudson's Hope is reached by trails on the north and south sides of Peace River. . . ." (Department of the Interior 1916h:258)
- "It is well known that Indian trails came north from McLeod Lake, ran down the Moberly River and turned north-east at the west end of Moberly Lake, crossed the Peace River downstream from Hudson's Hope and then continued on north to the Half-way River." (Calverley 1999i)
- "The road from East Pine via Dinner Creek on to Hudson's Hope and Fort St. John was the first pack trail." (Calverley 1999l)

6.2.1.1.1.9 Trail between Hudson's Hope and Rene Lake

A trail trending southwest of Hudson's Hope toward Rene Lake and Boucher Lake is shown on several of the reviewed historical maps of that area, first appearing on Brenot's 1912 map and the 1916f map (Brenot 1912a; Department of the Interior 1916d, 1916f, 1919, 1928; Canada Department of Lands 1922, 1928, 1931, 1936, 1945; Office of the Surveyor General 1922; Canada Department of Mines and Technical Surveys 1950; Canada Department of Lands and Forests 1963). The trail trends through the LAA, southwest from Hudson's Hope along the east side of Maurice Creek, then proceeds south of Rene Lake and east to Boucher Lake, before heading south towards Moberly Lake. This trail is absent from the B.C. Geographic Division (1963) and Canada Department of Lands, Forests, and Water Resources (1965) maps.

The trail is referenced in two of the reviewed historical sources (Calverley 1999l; Department of the Interior 1916h). Key quotations and excerpts that are relevant to this trail include the following:

- **1916 –** "Hudson's Hope is reached by trails on the north and south sides of Peace River. . . ." (Department of the Interior 1916h: 258)
- "The road from East Pine via Dinner Creek on to Hudson's Hope and Fort St. John was the first pack trail." (Calverley 1999l)

6.2.1.1.1.10 Trail between Hudson's Hope and Fort St. John (Hudson's Hope Road)

A trail between Hudson's Hope and Fort St. John, also referred to as the Hudson's Hope Road, is shown on each of the reviewed historical maps for that area, first appearing on the 1879-80 map (Geological Survey of Canada 1879-80; Brenot 1912a, 1914a; Canada Department of Lands 1912; Department of the Interior 1915, 1916a, 1916b, 1916c, 1916d, 1916f, 1917, 1918, 1919, 1920, 1928; Canada Department of Lands 1922, 1928, 1931, 1936, 1945; Office of the Surveyor General 1922; Canada Department of Lands and Forests 1963; B.C. Geographic Division 1963; Canada Department of Lands, Forests, and Water Resources 1965). In general, this road follows the current location of Highway 29, along the north side of the Peace River between Hudson's Hope and Fort St. John, and is largely located within the LAA.

One discrepancy between the mapped locations of this trail was noted at the Halfway River crossing. At this location, the five maps dating prior to 1928 show the trail crossing the Halfway River upriver of its current crossing.

Two trail routes east of the Cache Creek crossing were noted. The 1879-80 map shows the trail trending southeast from Cache Creek along the north bank of the Peace River through Jim Rose Prairie before trending northeast towards Charlie Lake and then south to Fort St. John. This route, which crosses Wilder Creek near its confluence, is also described as part of the "old police trail of '98" (Robinson 1973a:409). The 1919 map shows a second route, trending northeast immediately from Cache Creek, outside of the LAA, then following generally the current route of Highway 29 to Fort St. John. The description of this route as a "government road and telegraph line" on the 1918 map suggests that by this time this route was the main route for the Hudson's Hope Road. While the two 1922 maps differ in their description of the main route to Fort St. John (i.e., the telegraph line is shown as following separate routes on the two maps), the northeastern route from Cache Creek is shown as the main route on all subsequent maps. The southeastern route, while still appearing in some part on the maps, appears to become less prominent over time.

This trail is referenced in several of the reviewed historical sources (Bowes 1963; Butler 1963a; Calverley 1999i, 1999j, 1999k, 1999o; Department of the Interior 1916h; Canada Department of Lands 1929; Harrington 1963; Leitch 1950). Key quotations and excerpts that are relevant to the Hudson's Hope Road include the following:

- **1872 –** "First by land was William Francis Butler, journeying through the 'Wild North Land' in 1872. He made his way along the north bank and many a tourist has followed him. As settlement developed along the fertile benchlands of the river, the Indian trail he had followed became a pack-horse trail, then a wagon-road, and today a road adequate for motors. . . ." (Harrington 1963)
- **1873 –** "A trail, passable for horses, leads along the north shore of the river to this last trading-post of the Hudson's Bay Company [Hudson's Hope] on the verge of the mountains." (Butler 1963a:99)
- **1903 –** "Camped at Cache Creek in a regular swell place. Trail has been good all day and weather nippy. . . . Made a good early start and found trail in good shape." (Leitch 1950:96)
- **1905 –** "At Fort St. John the party split up. Inspector Richards, two corporals and thirteen constables were detailed ROW as a 'trail party' to follow the old blazed Moodie Mounted Police trail and widen it to eight feet. . . . The road must have followed very closely the present paved road [from Fort St. John] to Hudson's Hope since it went over the hills to come out above Bear Flats, dipped down there to river level, crossed Cache Creek and the Halfway River and on to The Hope. Corporal Profit's crew built 12 by 16-foot [3.7 m by 4.9 m] shelters every thirty miles, laid corduroy and built bridges where necessary." (Calverley 1999k)

- **1916 –** "Hudson's Hope is reached by trails on the north and south sides of Peace River. . . ." (Department of the Interior 1916h: 258)
- **1916 –** "This fractional township [Hudson's Hope] may be reached by boat on Peace River, by a pack-trail on the north shore of the river branching at Cache Creek from the trail to Fort Grahame. . . ." (Department of the Interior 1916h: 258)
- **1916 (1912) –** "A wagon road from Fort St. John runs westerly through the south part of Section 24, following the river flat, which rises gradually." (Department of the Interior 1916h: 245; Brenot 1912b)
- **1916 (1913) –** "The pack-trail from Fort St. John to Hudson's Hope crosses the flat in Sections 28, 29 and 33." (Brenot 1913a; Department of the Interior 1916h: 251)
- **1916 (1913) –** ". . .the pack-trails leading from Fort St. John to Fort Grahame and to Hudson's Hope, cross the township, the latter branching off from the main trail in Section 15." (Brenot 1913b; Department of the Interior 1916h: 248)
- **1916 –** "The Fort St. John and Hudson's Hope pack-trail, which was converted into a wagon road during the summer, passes about a quarter of a mile south of Sections 1, 2 and 3, thus providing an easy route by which the townships may be reached." (Department of the Interior 1916h: 252)
- **1916 –** "The Fort St. John and Hudson's Hope pack-trail, which has been improved sufficiently to allow the passage of wagons, runs parallel to Peace River along the northerly side of this flat. . . ." (Department of the Interior 1916h: 252)
- **1916 –** "There is also the Fort St. John-Hudson's Hope pack-trail running on the north side of Peace River." (Department of the Interior 1916h: 252)
- **1928 –** "After completing the Halfway River surveys in August we moved our outfit south, following the Indian trails to the Hudson's Hope country, and commenced work northerly from where we had left off the previous season at the Rocky Mountain Portage." (Canada Department of Lands 1929:10)
- "It is well known that Indian trails. . . crossed the Peace River downstream from Hudson's Hope and then continued on north to the Half-way River." (Caverley 1999k)
- "The road from East Pine via Dinner Creek on to Hudson's Hope and Fort St. John was the first pack trail." (Calverley 1999l)
- "The mailman drove a team of mules – he never missed a trip and was seldom late. Once the team and wagon slipped off 'The Hump', a notorious single-track road over a hill of the greasiest clay imaginable." (Calverley 1999j)
- "Jim Rose Prairie is the 'flat' below Bear Flat and down river from 'The Slide'. It was on the old police trail of '98." (Robinson 1973a:409)

6.2.1.1.1.11 Trail between Fort Grahame and Fort St. John

A trail between Fort Grahame on the Finlay River and Fort St. John is shown on each of the historical maps reviewed for that area, first appearing on the 1916a map (Department of the Interior 1916a, 1916g, 1918, 1919, 1928; Canada Department of Lands 1922, 1928, 1931, 1936, 1945; Office of the Surveyor General 1922; Canada Department of Lands and Forests 1963; Canada Department of Lands, Forests, and Water Resources 1965). This trail trends east into the LAA along the north side of Cache Creek, continuing southeast to the Hudson's Hope Road. The trail then proceeds southeast along the north bank of the Peace River, on the section of trail previously described as the southern route of the Hudson's Hope Road.

This trail is referenced in five of the reviewed historical sources (Calverley 1999f, 1999q; Clare 1998b; Department of the Interior 1916h; Howarth 1917). Key quotations and excerpts relevant to this trail include the following:

- **1898 –** "Police Superintendent Constantine, Inspector Richard, 6 non-commissioned officers, 22 constables and 60 horses set off from Fort St John [in 1905] to build a proper road to the Yukon, complete with rest shacks every 30 miles or so." (Clare 1998b) [While it is known that this trail followed the earlier trail blazed by Moody in 1898, there is some discrepancy as to the original location of the Moody trail in this area with some references placing his trail along the Halfway River.]
- **1905 –** "[Bill Carter] moved into Hudson's Hope about 1906 after helping put in police trail from Fort St. John to Fort Grahame in 1905." (Calverley 1999q)
- **1916 –** "This township may be reached by the pack-trail leading from Fort St. John to Fort Grahame which passes through Sections 32, 33, 28 27, 34 and 35." (Department of the Interior 1916h: 248)
- **1916 (1913) –** "The old pack-trail leading from Fort St. John to Fort Grahame passes through Sections 1 and 6 of this township. This was formerly an old Indian trail, but it was improved by the Royal North-west Mounted Police during the rush to the Klondike, and still serves as the main trail to Fort Grahame though it passes through very rough country and crosses numerous deep valleys." (Department of the Interior 1916h: 248; Brenot 1914b)
- **1916 (1913) –** ". . .the pack-trails leading from Fort St. John to Fort Grahame and to Hudson's Hope, cross the township, the latter branching off from the main trail in Section 15." (Department of the Interior 1916h: 251; Brenot 1913b)
- **1916 –** Tp. 84, Range 22: ". . .the pack-trail between Fort St. John and Fort Grahame crosses the east outline of Section 24." (Department of the Interior 1916h: 252)
- **1916 –** "A wagon road from Fort St. John runs westerly through the south part of Section 24, following the river flat, which rises gradually." (Department of the Interior 1916h: 245)
- **1917 –** "A trail cut out by the Royal Northwest Mounted Police in the days of the Klondike rush passes Fort Grahame on the way from Fort St. John on Peace River, two hundred and eighteen miles distant, to the Telegraph Trail and the Skeena River, but it has not been kept cleared and is now practically impassable. The trail was at one time practicable for pack-horses. . . ." (Howarth 1917)
- "The only passable trail, used in winter as late as the 1940's, was the old Trail of '98 up the winding Halfway towards Fort Grahame. . . the old Trail of '98 to Fort Grahame, made a long loop following the Halfway Valley." (Caverley 1999g)

6.2.1.1.1.12 Trail between Fort St. John and Dunvegan

A trail between Fort St. John and Dunvegan, beyond the LAA, is labelled as such on one of the reviewed historical maps (Department of the Interior 1916a). The trail trends north from Fort St. John and is referenced in two of the reviewed historical sources (Ogilvie 1892; Leitch 1950). Key quotations and excerpts relevant to this trail include the following:

- **1892 –** "There is an old pack trail on the north side of the river between St. John and Dunvegan" (Ogilvie 1892).
- **1903 –** "Staying at Dunvegan. . . . Made a break for St. John and found trail in an awful state. . . . Only made six miles. . . . Made about 8 miles in the day. . . . Trail in a terrible state. . . . Made 8-10 miles. . . . Trail still in bad state and breaking road as bad. . . . Made 11 miles. . . . Trail improved. . . . Feel much encouraged by trail and expect to make St. John by Tuesday night. . . . Made a good trip probably 12 miles. . . . Good journey of 18 miles. Passed North and South Pine. . . . Struck St. John early in the afternoon." (Leitch 1950:94-95) [Excerpts from horseback journey in the spring of 1903.]

6.2.1.1.1.13 Trail between Fort St. John and Moberly Lake

A trail between Fort St. John and Moberly Lake is shown on several of the reviewed historical maps, first appearing on the 1912 map (Canada Department of Lands 1912, 1922, 1928, 1931, 1936, 1945; Department of the Interior 1916a, 1916e, 1919, 1928; Office of the Surveyor General 1922; Canada Department of Lands and Forests 1963; Canada Department of Lands, Forests, and Water Resources 1965). This trail initially leads southwest from Fort St. John along the northwest side of the Pine River, before continuing southwest towards Moberly Lake. Some discrepancies as to the location of this trail were noted south of Fort St. John:

- The 1912 map shows the trail trending due south to Pine River and then southwest towards Moberly Lake.
- Five subsequent maps show the trail trending immediately southwest towards Moberly Lake from the south bank of the Peace River (Department of the Interior 1919; Canada Department of Lands 1922, 1931, 1936; Office of the Surveyor General 1922).
- Four maps show the trail trending first southeast from Fort St. John before trending southwest towards Moberly Lake (Department of the Interior 1928; Canada Department of Lands 1928, 1945; Canada Department of Lands and Forests 1963).
- The 1965 map also shows this trail as crossing the Peace River further downstream than indicated on the previous maps.

This trail is labelled on both the 1916a and 1916e maps as a "trail from Hudson's Hope to Fort St. John." As such, this route would have followed the trail that trends southwest to Moberly Lake and then north to Hudson's Hope, either along the "trail from Hudson's Hope to Rene Lake" or the "trail from Hudson's Hope to Moberly Lake."

6.2.1.1.1.14 Trail between Fort St. John and Pouce Coupe

A trail between Fort St. John and Pouce Coupe, beyond the LAA, is shown on several of the reviewed historical maps, first appearing on the 1912 map (Canada Department of Lands 1912, 1922, 1928, 1931, 1936, 1945; Department of the Interior 1916a, 1916e, 1919, 1928; Office of the Surveyor General 1922; Canada Department of Lands and Forests 1963; Canada Department of Lands, Forests, and Water Resources 1965). This trail trends southeast from Fort St. John along the south bank of the Peace River before continuing east. The location of this trail remains relatively consistent within the reviewed maps, with the exception of the 1945 and 1963 maps, in which the trail trends southeast for only a short distance, then proceeds southwest to the north side of the Pine River before continuing southeast once more. In addition, the 1965 map shows the trail crossing the Peace River further downstream from the previous Fort St. John crossing.

6.2.1.1.1.15 Trail to Fort McLeod

A trail located along the south side of the Pine River, beyond the LAA, is shown on the 1879-80 map (Geological Survey of Canada 1879-80). This trail trends east–west along the south side of the Pine River. A campsite, dated to July 30-31, is also shown on this map. It is assumed that this campsite refers to a location used by the surveyor for this map. Four subsequent maps show a trail along the north bank of the Pine River at this location (Canada Department of Lands 1928, 1931, 1945; Canada Department of Mines and Technical Surveys 1950). This northern trail is labelled as a “trail to Fort McLeod” on both the 1928 and 1931 maps. The 1945 map also shows a trail along the south side of the Pine River. In addition to a railway grade along the north side of the Pine River, the southern trail (now a road) is shown on the more recent maps (Canada Department of Lands and Forests 1963; B.C. Geographic Division 1963; Canada Department of Lands, Forests, and Water Resources 1965).

6.2.1.1.2 Minor or Unnamed Trails

6.2.1.1.2.1 Hudson’s Hope Vicinity

A number of minor, unnamed trails are shown on the reviewed historical maps in the vicinity of Hudson’s Hope. One of these trails proceeds north from Hudson’s Hope before splitting into two trails, one trending northwest and the other northeast (Canada Department of Lands 1912; 1917; Canada Department of Lands 1922, 1928, 1931, 1936, 1945; Office of the Surveyor General 1922; Department of the Interior 1916f, 1919, 1928; Canada Department of Lands and Forests 1963; Canada Department of Lands, Forests, and Water Resources 1965). One of the 1928 maps (Department of the Interior 1928) labels the northwest divergence of this trail as “from Chinaman Lake." Another trail is shown trending southwest along the northern bank of the Peace River (Department of the Interior 1916f, 1919, 1928; Canada Department of Lands 1922, 1928, 1931, 1936; Office of the Surveyor General 1922), but it is not present on the 1945 map. A trail is also shown trending southwest along the southern bank of the Peace River, immediately southwest of Hudson’s Hope (Department of the Interior 1916f, 1919, 1928; Canada Department of Lands 1922, 1928, 1931, 1936, 1945; Office of the Surveyor General 1922; Canada Department of Lands and Forests 1963). This trail is no longer present on the 1965 map. A trail is, however, shown on the 1965 map, trending northwest from the Rocky Mountain portage trail and through Bullhead Mountain.

6.2.1.1.2.2 Farrell Creek Vicinity

A trail west of Farrell Creek, proceeding north from the Hudson's Hope Road, is shown on several of the reviewed historical maps, first appearing on the 1914 map (Department of the Interior 1916b, 1919, 1928; Canada Department of Lands 1922, 1928, 1931, 1936, 1945; Office of the Surveyor General 1922; Canada Department of Lands, Forests, and Water Resources 1965). A second trail, located further west of this location, is shown trending northwest from the Hudson's Hope Road on one of the 1963 maps (Canada Department of Lands and Forests 1963) and on the 1965 map. A third trail, located east of Farrell Creek, is also shown trending north and then east from Hudson's Hope Road on the 1945 map.

6.2.1.1.2.3 Halfway River – Attachie Vicinity

A small network of trails is shown on the 1915 map along the east side of the Halfway River (Department of the Interior 1915). One of these trails terminates east of the Halfway River at the edge of the Peace River. This same trail is shown on the 1936 map, trending further east to reconnect with the Hudson's Hope Road (Canada Department of Lands 1936). A trail is also shown on several of the maps trending northwest from the Hudson's Hope Road, immediately east of the Halfway River, and first appearing on the 1919 map (Department of the Interior 1919; Canada Department of Lands 1922, 1928, 1931, 1936, 1945; Office of the Surveyor General 1922; Department of the Interior 1928; Canada Department of Lands, Forests, and Water Resources 1965). This trail may be the route referenced in one of the reviewed historical sources (Clare 1998b):

- **1897 –** "Herchmer told Moodie that, in his opinion, the best route was from Fort St John, up the Peace River to the Halfway, then up the Halfway to Frances Lake and into the Trench by way of the then nameless Laurier Pass. From there, the Commissioner was sure it was possible to strike the junction of the Liard and Dease Rivers, although the preferred target was to be Pelly Banks on the Klondike River. The route selected by Moodie was to be by land and practicable, where possible, for wagons and always for pack horses." (Clare 1998b)

A trail is also shown along the west side of the Halfway River on the 1945 map, trending west across the northern Halfway River crossing and then south to Hudson's Hope Road (Canada Department of Lands 1945). The later 1963 and 1965 maps show a number of trails trending to the northwest off the Hudson's Hope Road, east of the Halfway River (Canada Department of Lands and Forests 1963; Canada Department of Lands, Forests, and Water Resources 1965).

6.2.1.1.2.4 Cache Creek – Bear Flat Vicinity

A trail trending north from the trail from Fort Grahame to Fort St. John and, immediately east of Cache Creek is shown on several of the reviewed historical maps (Department of the Interior 1916g, 1919, 1928, 1936, 1945; Office of the Surveyor General 1922). A larger network of trails is also shown in the vicinity of Wilder Creek, first appearing on one of the 1928 maps (Department of the Interior 1928). Many of these trails connect with the northern route of the Hudson's Hope Road. A trail is also shown on the 1918 map trending northeast through the dam site development area (Department of the Interior 1918).

6.2.1.1.2.5 Fort St. John Vicinity

A large network of trails in the vicinity of Fort St. John is shown on several of the reviewed historical maps, first appearing on the 1916 map (Department of the Interior 1916a, 1918, 1919, 1920, 1928; Canada Department of Lands 1922, 1928, 1931, 1936, 1945; Canada Department of Lands and Forests 1963, Canada Department of Lands, Forests, and Water Resources 1965; Office of the Surveyor General 1922). The number of these trails increase over the years and are shown in various locations throughout the vicinity. The trails and roads around Fort St. John appear to begin by following property boundaries (i.e., north–south and east–west) on the 1928 maps. One of these 1928 maps also shows a large network of trails in the vicinity of Grandhaven (Department of the Interior 1928). A number of trails appear to converge on the north bank of the Peace River east of Wilder Creek on the 1936 map.

6.2.1.1.2.6 South of the Peace River

A network of trails is shown on the south side of the Peace River on several of the reviewed historical maps, first appearing on the 1919 map (Department of the Interior 1919, 1928; Canada Department of Lands 1922, 1928, 1931, 1936, 1945; Canada Department of Lands and Forests 1963, Canada Department of Lands, Forests, and Water Resources 1965; Office of the Surveyor General 1922). These trails cross the transmission line in a number of locations and increase in frequency over time. The 1963 map and one 1965 map show a number of northeast–southwest and northwest–southeast trending trails (likely seismic lines) within the LAA, on the south side of the Peace River opposite the mouth of the Halfway River (Canada Department of Lands and Forests 1963; Canada Department of Lands, Forests, and Water Resources 1965).

6.2.1.1.2.7 River Crossings

An important factor in trail location was where river crossings were practical. Some river crossings are shown and described on the 1936 map (Canada Department of Lands 1936). These include a “rowboat ferry” and “ford” at the Halfway River crossing, and a “ford” at the Cache Creek crossing. Peace River crossings are referenced in a number of the reviewed historical sources, including:

- A “rowboat ferry,” immediately south of Hudson’s Hope, linking Hudson’s Hope with the Moberly Lake trail and the former site of the Hudson's Bay Company post. By 1950, one of the narrow former freight boats was maintained by the provincial government as a local ferry between Hudson's Hope and the south bank (Harrington 1963). Between the times that the rowboat ferry and the freight boat were in use, a cable ferry was employed, consisting of a suspended basket moved back and forth across the river (Harrington 1963). The ferry crossing at Hudson’s Hope was abandoned with the construction of the Hudson’s Hope suspension bridge in 1967.
- Two fords on the Halfway River, one “at the confluence of the Peace and the other in Section 30” (Brenot 1913a).
- A “historically used ford” located about 6 km east of Cache Creek was recorded as archaeological site HbRh-35 in 1976. One map from 1928 (Canada Department of Lands 1928) shows a road leading down from the Hudson’s Hope Road to a point near the reported ford. There are no trails or roads evident on the south bank anywhere near this location, until a possible trail (or seismic line) is shown on the 1963 map (Canada Department of Lands and Forests 1963).
- A ford was reported at the mouth of “Deep Creek” (Wilder Creek) where the “Moberly Lake Indians could cross horses. . . to the South Side of the Peace” (Robinson 1973a:409).

- The pattern of trails converging at both sides of the river at Fort St. John II and Fort St. John III indicates that crossings were common at this point, but whether a ferry service was established is not clear. In 1920, a cable ferry was built at Taylor Flat. The cable proved vulnerable to driftwood and was soon replaced with a small gas boat and scow (Tower 1981). This scow and tug ferry service, or "power ferry," connected the Fort St. John community with the south bank of the Peace River until the Alaska Highway suspension bridge was constructed at this site in 1942.

6.2.1.1.3 Developing Economies – Communication

A telegraph line appears on the 1919 map (Department of the Interior 1919) and parallels the trail from Hudson's Hope to Fort St. John. The telegraph line is shown on both the 1919 map and on one of the 1922 maps (Office of the Surveyor General 1922) to deviate from the Hudson's Hope Road immediately south of Charlie Lake, trending south and then east to Fort St. John. The 1928 map (Canada Department of Lands 1928) shows the telegraph line following the trail from Hudson's Hope to Fort St. John for its entire route. The 1945 map (Canada Department of Lands 1945) has the telegraph line deviating from Hudson's Hope Road near Charlie Lake, trending east to the trail that is located along the west side of Charlie Lake, then following this trail southeast to Fort St. John.

The telegraph line is referenced in two of the reviewed historical sources (Bowes 1930; Canada Department of Lands 1929). Key quotations relevant to the telegraph line include the following:

- **1915 -** "A telegraph line came in [Fort St. John], in 1915." (Bowes 1930)
- "It is expected that the Dominion Government Telegraph Line will be completed to St. John this year and will shortly be extended to Hudson's Hope." (Canada Department of Lands 1929)

6.2.1.1.4 Developing Economies – Extraction and Production

Four of the reviewed sources document coal mining activities in the vicinity of Hudson's Hope (Howarth 1917; Kyllo 2003; Leitch 1950; Maurice 1947). Leitch (1950) provides an early, first-hand account of coal prospecting in the Peace River Canyon circa 1903. Maurice (1947) comments that coal mining was the main industry for Hudson's Hope, with four mines there being worked on a small scale.

In addition to coal mining, Williams (1963:167) notes the presence of tufa deposits on the north bank of the Peace River, just west of Hudson's Hope. He describes one of the deposits as being 30 ft. high and extending for approximately 1,500 ft. along the river bank. He comments that the HBC formerly burnt the tufa to produce quicklime, to supply the community at Hudson's Hope.

In referring to the lands around Halfway River, one source indicates that, "[a] considerable quantity of gold dust has been taken out of some of the gravel-bars along this part of Peace River, and Half-way River is supposed to be a paradise for the miner and hunter. . . ." (Pike 1963:155)

One source also refers to the discovery of gold deposits in the Peace River and comments that, "[i]n 1919 Fort St. John had another source of excitement–gold was found in the river. Dredging outfits were sent in, but the silt was too fine to be handled and the gold was not in sufficient quantities to make it profitable." (Bowes 1930).

6.2.1.1.5 Settlement

Several historical settlements are located in the vicinity of the LAA. For the purposes of this report, a discussion of property boundaries is not included, as these boundaries may or may not correspond to historical structures present in the LAA and adjacent areas. As such, emphasis is placed on documenting the locations of structures referenced in the historical literature or shown on the historical maps.

A landmark date in the settlement and development of the upper Peace River region is 1912. The completion of the Edson – Grande Prairie Trail from Edmonton to Peace River Crossing in 1911 brought a new settlement boom into the area. Survey and subdivision for the purposes of settlement of Dominion lands in the upper Peace River Region also began in 1911. In 1912, a rush of settlement occurred when the Peace River Block, an area of approximately 9,425 ha (75 sq. mi.), extending from the border between British Columbia and Alberta to Hudson's Hope, was opened for settlement (Calverley 2009o; Cran 1973:392). A subsequent settlement boom occurred with completion of the ED&BC Railway in 1916. During the Great Depression, many sojourners from dried out farms in southern Alberta and Saskatchewan moved into the Peace River area as it was not affected by the drought.

The results of the literature review related to historical settlements within the LAA are described below.

6.2.1.1.5.1 Hudson's Hope

The settlement of Hudson's Hope is shown on several of the reviewed historical maps, first appearing on the 1879-80 map (Geological Survey of Canada 1879-80; Canada Department of Lands 1912, 1922, 1928, 1931, 1936, 1945; Department of the Interior 1919, 1928; Office of the Surveyor General 1922; Canada Department of Lands and Forests 1963; B.C. Geographic Division 1963; Canada Department of Lands, Forests, and Water Resources 1965). The 1879-80 and 1912 maps both show that Hudson's Hope was then located on the south side of the Peace River. In all later maps, Hudson's Hope is shown in its current location on the northwest side of the Peace River. The 1879-80 map also shows an "old Hudson's Hope" on the north side of the Peace River, immediately northeast of Middle River (also known as Halfway River). This corresponds to the present location of the settlement of Attachie.

A number of structures are indicated on the historical maps at Hudson's Hope. These include: 1) a sub-mining recording office, a post office, and a telegraph office, first shown on both the 1922 maps; 2) a school, first shown on the 1928 map; and 3) a hospital, first shown on the 1963 map. These structures appear on the majority of the subsequent maps, although the exact locations vary slightly. The 1928 map also shows several "buildings" in the vicinity of Hudson's Hope, on both sides of the Peace River and along Hudson's Hope Road to the northeast.

The settlement of Hudson's Hope is referenced in several of the reviewed historical sources (Akrigg and Akrigg 1975; Bowes 1963; Burley, et al. 1996; Butler 1963a; Calverley 1973, 1999b, 1999e, 1999g; Canada Department of Lands 1929; Footner 1963; Galloway 1963a, 1963b; Gordon 1963; Harmon 1963; Harrington 1963; Howarth 1917; Kyllo 2003; MacGregor 1952; Maurice 1947; McLaughlin 1999; Morse 1969; Patterson 1963; Pike 1963; Ventress, et al. 1973:H4-H9; Wallace 1929). Key quotations and excerpts relevant to Hudson's Hope include the following:

- **1805 –** "James MacDougall was sent from Rocky Mountain Fort to the eastern end of the Peace River Canyon to establish a post on elevated land opposite the current town of Hudson's Hope. Later named Rocky Mountain Portage House, it served as the replacement for Rocky Mountain Fort in 1805." (Burley, et al. 1996:32-33)

- **1805 –** "In late fall of 1805, Simon Fraser established a new post at the easterly end of the great portage to pass the rapids of Peace River at modern Hudson's Hope [Rocky Mountain Portage]." (Wallace 1929)
- **1810 –** "After his first trip across the mountains, Simon Fraser came back as far as the foot of the Peace River Canyon and wintered at a post called Rocky Mountain Portage House, across the river from present-day Hudson's Hope. In 1810 the post was relocated to the North side of the River." (Calverley 1999g)
- **1873 –** ". . .a solitary house called Hudson's Hope." (Butler 1963a:99)
- **1882 –** "That year [Tom Kerr] was sent temporarily to manage the company's post at Hudson's Hope that had been in operation since 1805." (McLaughlin 1999:21)
- **1902 –** "The Hudson's Hope post was open only in the winters and [Frank] Beatton was there in 1902." (Calverley 1973)
- **1903 –** "Made the Hope about four o'clock and went into camp around the point on South Bank. In the evening we visited Mr. McDiarmid, the H.B. Factor. . . ." (Leitch 1950:96)
- **1912 –** "The trading-post at Hudson's Hope is opened only in the winters for convenience of the fur-trade. When we were there the little store was boarded. . . . All the old company posts throughout the North were erected with an unerring eye for a romantic and impressive effect, and this one was no exception. It stands in a wide, grassy esplanade on top of the bank, which is here some two hundred feet high." (Footner 1963)
- **1912 –** "Hudson's Hope consists of two pairs of log buildings, belonging to the Hudson's Bay Company and Revillon Freres respectively, but neither are occupied at the moment. The Indians are all away hunting, and the factors are sometimes withdrawn from some of the smaller posts during the off season. A few settlers have taken up land here within the last couple of years, and, although there is a good bit of clearing to do anywhere on the north side of the river, they have been industrious and have already the tidy beginnings of ranches. On the south side of the river the flat valley bottom extends back for a couple of miles, a splendid townsite, which has already been seized upon by speculators, a number of whom have 'squatted' on land and built log cabins, remaining on it long enough to fulfill the legal requirements for a homestead. . . ." (Galloway 1963a:298-299)
- **1912 –** "When we came in 1912 we were the first white women who came to live here west of Dunvegan. That fall Mr. Drew, HBCo. Trader brought his white wife there to Hudson's Hope and a son was born there, so far as we know the first white child at Hudson's Hope. I think it was two years later Mr. and Mrs. Learmoth had a son born to them there and the present Mrs. Jim Beattie has three children born there." (Calverley 1999b)
- **1912 –** ". . .a little two-room log cabin which, in 1912, had served as a post office and the dwelling of the first postmaster. Occasionally trappers, in from the bush for a short time, still camped in this building." (Kyllo 2003:139)
- **1917 –** ". . .the dozen or so cabins that I knew must constitute the famous settlement of Hudson's Hope, before one of the most considerable of these structures rose the inevitable flagpole that marks a Hudson's Bay post. . . . On a flat across the river and some distance farther down-stream, lies the old site of Hudson's Hope, and it is worth remarking that on most maps the post is still placed on the south side of the Peace." (Howarth 1917:269)
- **1917 –** "Hudson's Hope is a small unpretentious establishment. . . . The Indians were all encamped in their moose-skin lodges on the flat close to the fort waiting for the trade to begin." (Pike 1963:155)

- **1928 –** "I may add that at this point there are two stores which hitherto had been merely trading-posts for Indian trade; but in order to meet the requirements of travelers and settlers (about forty of whom have taken up homesteads in the immediate vicinity during last, summer) the stocks of merchandise have been materially enlarged to meet the expanding demand of the country." (Canada Department of Lands 1929)
- **1947 –** "There is a Hudson's Bay trading post, hotel, stores and a neat little Anglican church made of rounded logs." (Maurice 1947:93)
- **1950 –** "The Hudson's Bay Company buildings are strictly modern, having been built in 1942. A log garage is the sole survivor of the older buildings constructed on the north bank about 1882. No one could tell us just when they had been set up on the south bank. When Alexander Mackenzie made his epic journey of 1793, only the framework of Indian teepees stood there." (Harrington 1963)
- **1955 –** "All that can be seen now [of the old post] is the faint excavations of old cellars, a few corner rocks and the half buried mounds of chimney stones." (Patterson 1963:510)

Additional sources describe individual cabins, homesteads, and "squats" in the vicinity of Hudson's Hope (Brenot 1912a; Department of the Interior 1916h; Calverley 1999a, 1999b, 1999q; Leitch 1950). See Kyllo (2003:80-82, 135-138) for information on land applications and a list of homesteader in Tp. 80 to Tp.84 of the Peace River Block, extending east from Hudson's Hope. Other sources reference small trading posts and settlements east of Hudson's Hope, in the Peace River Canyon (Howarth 1917; Pike 1963).

Regarding historical sites that have been previously recorded in the Provincial Heritage Register, there are three such historical sites recorded in the LAA in the vicinity of Hudson's Hope, including HaRl-4 (Rocky Mountain Portage House), HaRl-5 (a historical campsite), and HaRl-28 (a canoe skid, in which cobbles have been cleared away on the shore and a linear feature remains). In addition, sites HaRk-9 (a homestead) and HaRk-33 (Robinson homestead) are recorded northeast of the community of Lynx Creek.

6.2.1.1.5.2 Farrell Creek

The settlement of Farrell Creek is shown on four of the reviewed historical maps, first appearing on the 1936 map (Canada Department of Lands 1936, 1945; Canada Department of Lands and Forests 1963; Canada Department of Lands, Forests, and Water Resources 1965). A post office is shown in association with this settlement and appears on both the 1936 map and the 1945 map. A school west of Farrell Creek is also shown on the 1945 map, a considerable distance southwest of the modern settlement of Farrell Creek. While the Farrell Creek settlement is shown on the remaining two maps, no structures are portrayed. While not specifically labelling this location as the settlement of "Farrell Creek," the 1928 map shows several "buildings" in the vicinity of Farrell Creek, including: (1) two west of the creek itself, (2) two on the south side of the Peace River across from the creek mouth, and (3) one located along the Hudson's Hope Road near the Farrell Creek settlement.

Several of the reviewed historical sources reference homesteads in the vicinity of Farrell Creek (Ardill 1973; Bowes 1963; Brenot 1914a, 1915; Calverley 1999a, 1999q; Department of the Interior 1916h). The earliest reference to settlement identified in the reviewed historical sources is attributed to Harry Farrell in 1910 (Calverley 1999q). Other named early settlers in the vicinity include Joe Zelinka (who took over the Farrell property), Donald (Dan) MacDonald (1910) (Calverley 1999q), the Erb Brothers (Calverley 1999a), and the Ardills (1920) (Ardill 1973).

Ten historical sites in the Farrell Creek locality and the lands northeast toward the Halfway River in the LAA are identified in the Provincial Heritage Register. These sites include HaRk-10 (Rutledge cabin), HaRk-13 (homestead), HaRk-16 (homestead), HaRj-23 (Moody or Townsend homestead), HaRk-29 (Beattie homestead), HaRk-32 (Forsythe cabin), HaRk-34 (Farrell cabin), HaRk-38 (homestead), HbRj-6 (historical artifacts) and HbRj-10 (historical cultural depressions and artifacts).

6.2.1.1.5.3 Attachie

The settlement of Attachie is shown on six of the reviewed historical maps, first appearing on the 1928 maps (Department of the Interior 1928; Canada Department of Lands 1928, 1931, 1936; Canada Department of Lands and Forests 1963; Canada Department of Lands, Forests, and Water Resources 1965). As previously described, this area is shown on the 1879-80 map as being the location of "old Hudson's Hope" (Geological Survey of Canada 1879-80). The settlement is alternatively identified as "Halfway River" on some of these maps. One 1928 map (Canada Department of Lands 1928) indicates that a telegraph office was located at this settlement; however, the exact location of this structure is not shown. A school is shown on the remaining five maps, varying slightly in location, but consistently located on the east side of the Halfway River. A post office is also indicated on the 1936 map, east of the Halfway River. One of the 1928 maps (Department of the Interior 1928) indicates the location of three "buildings" in the vicinity of Attachie, all located on the east side of the Halfway River.

Several of the reviewed historical sources reference homesteads in the vicinity of Attachie (Bowes 1963; Brenot 1913a; Calverley 1999m, 1999q; Department of the Interior 1916h; Kyllo 2003). The earliest reference to settlement near Attachie in the historical sources is attributed to a "Mr. Brady," who is identified by another early settler (George Hunter) as having arrived in 1912 as the first homesteader in the Halfway locality (Caverley 1999p). Additional, named, early settlers in the vicinity include George Hunter, Douglas and Howard Cadenhead (1912), and Ed Forfar (1917) (Calverley 1999q; Ventress, et al. 1973). Douglas Cadenhead was a well-known river pilot and captain (Galloway 1963b). Five unnamed "squatters" are reported to have occupied the area in 1916 (Department of the Interior 1916h).

One site in the vicinity of Attachie with historical artifacts (HbRi-10) is recorded in the Provincial Heritage Register.

6.2.1.1.5.4 Bear Flat

A settlement at Bear Flat is shown on seven of the reviewed historical maps, first appearing on the 1928 maps (Canada Department of Lands 1928, 1931, 1936, 1945; Department of the Interior 1928; Canada Department of Lands and Forests 1963; Canada Department of Lands, Forests, and Water Resources 1965). A post office is shown on the east side of Cache Creek on each of the maps, varying in its exact position. A school is shown on the west side of Cache Creek on one of the 1928 maps (Canada Department of Lands 1928), but is absent on the 1945 map and the other 1928 map (Department of the Interior 1928). The 1931 and 1945 maps do indicate a school is located on the east side of Cache Creek, but vary in its exact position. The 1963 and 1965 maps again locate the school on the west side of Cache Creek, but further west along the Hudson's Hope Road than the previous location. One of the 1928 maps (Department of the Interior 1928) shows the location of three "buildings" in the vicinity of Bear Flat, all of which are east of Cache Creek. A number of "buildings" are shown on this map, to the southeast of Bear Flat near Wilder Creek and along the southern route of the Hudson's Hope Road.

Seven of the reviewed historical sources reference camps or homesteads in the Bear Flat area (Bowes 1963; Brenot 1913b; Burley, et al. 1996; Calverley 1999h; Department of the Interior 1916h; Dopp Hipkiss 1973; Robinson 1973b). In 1793, Alexander Mackenzie wrote of overnighting at either Bear Flat or Jim Rose Prairie on his journey westward, noting that, "the land above the spot where we encamped, spreads into an extensive plain, and stretches on to a very high ridge, which in some parts, presents a face of rock, but is principally covered in verdure [i.e., vegetation]" (Burley, et al. 1996:7). George Freer is identified as the first "squatter" in that area, having settled in 1912 (Calverley 1999h). Brenot (1913b) notes that that "[o]ne squatter was found on a flat in Section 15 and he has been there for nearly three years" (see also Department of the Interior 1916h).

The Provincial Heritage Register identifies six historical sites recorded from the Bear Flat – Cache Creek vicinity. These include HbRg-28 (Flatt – Freer homestead), HbRh-2 (_____), HbRh-35 (cultural depressions and artifacts), HbRh-45 (cultural depression), HbRh-60 (Dopp homestead and Bear Flat School; see Dopp Hipkiss 1973:52-56), and HbRh-61 (Watson homestead).

6.2.1.1.5.5 Old Fort St. John

Although outside of the LAA, Fort St. John is discussed below due to its importance in the historical development of the LAA. The original settlement at Fort St. John is shown on several of the reviewed historical maps, first appearing on the 1879-80 map (Geological Survey of Canada 1879-80; Department of the Interior 1919, 1928; Canada Department of Lands 1912, 1922, 1928, 1931, 1936, 1945; Office of the Surveyor General 1922; Canada Department of Lands and Forests 1963; B.C. Geographic Division 1963; Canada Department of Lands, Forests, and Water Resources 1965). Both the 1879-80 and 1912 maps show Old Fort St. John located immediately upon the north bank of the Peace River. A map coordinate is also provided on the 1879-80 map for the location of Old Fort St. John. Several structures are shown on the maps, including a post office, mining recorder's office, telegraph office, Dominion Lands Agency office, school, and hospital. The 1936 map also shows the location of several "buildings" in the vicinity of Old Fort St. John. Minor variations in the exact position of these structures were observed among various maps.

There is extensive documentation on historical fur trade post locations in the Fort St. John vicinity (see Fladmark 1975; Spurling, et al. 1976; Burley, et al. 1996). The different iterations of the posts near the town of Fort St. John can be described as follows. After Mackenzie travelled through the Peace River region in 1793 on his journey westward, the NWC established Rocky Mountain Fort near the mouth of the Moberly River in 1794. This post operated until 1804. In 1805, the post of St. John's at the mouth of the Beatton River was established. The HBC established Yale's House in 1820 at the former location of Rocky Mountain Fort. In 1821, the post at St. John's was renamed D'Epinette upon the amalgamation of the NWC and the HBC. This post continued in use for two more years, until 1823. Following its abandonment, subsequent St. John's posts were established to the north and south of the Peace River, south of the modern-day location of the City of Fort St. John (Burley, et al. 1996).

Many historical sources describe several forts in the vicinity of Fort St. John (Barman 1991; Bowes 1930, 1963; Butler 1963b; Pettit 2008; Calverley 1999g; Soars 1952). Key quotations and excerpts relevant to Fort St. John include the following:

- **1794 –** "In 1794, Rocky Mountain Fort was erected at the junction of the Moberly River and the Peace, one of the first European establishments in the territory crossed by Alexander Mackenzie the year before." (Pettit 2008:62)

- **1805 –** "The older Peace post was moved to the main trail and another post named Fort St. John's was established nearby." (Barman 1991:37)
- **1805 –** In 1805, the North West Company built another fort several miles downstream at the mouth of the Beatton River and named it St. John's." (Pettit 2008)
- "Fort St. John has seen many vicissitudes. It has been moved at least five times, from one side of the river to another." (Soars 1952)
- **1873 –** "The fort of St. John is a very tumble-down old place; it stands on the south shore of the river, some thirty feet above high-water level; close behind its ruined buildings the ridges rise 1,000 feet. . . . On the north shore of the river, directly facing the tumble-down fort, a new log-house was in course of erection by the Hudson's Bay Company. Work moves slowly in the North, and this log-house lay long unfinished." (Butler 1963b:94)
- **1881 –** "In 1881, the company transferred Kerr to the historic post at Fort St. John. Actually Fort St. John was located in many places in its day. The company had a habit of moving from location to location, along the river, often because of disputes over land. Private traders in the region tried their best to make life miserable for Bay employees along the Peace River." (McLaughlin 1999: 20)
- "The real history of Fort St. John starts in 1805 as a fur trading post on the North Pine River. After one or two moves to other locations, the last site of Fort St. John on the river below the town was chosen in 1870. It is a very pretty spot and most tourists visit it. Two fur companies had posts -- Revillon Freres and Lampson & Hubbard." (Bowes 1930)
- "A few HBCo. forts were built further up the Peace - Yale's House a little below Fort St. John. Whichever company built a post, the other would come along to build another close beside it. For example, at the now forgotten and lost site of Yale's House, John McIntosh of the Nor[th]west Company built close beside him." (Calverley 1999g)
- "The last relics of the old days in this area are. . . the museum building at Hudson's Hope, and a little shed there constructed in the old log fashion - and some tumble-down ruins of some of the various old Fort St. Johns." (Calverley 1999g)

Additional quotations and excerpts describing Fort St John's developing economy and the building of social and community life include the following:

- **1802 –** "Still there is the mystery of the name 'Fort St. John'. . . . According to the history of the Church in Montreal, 'a brigade coming West from Montreal expressly to set up a new trading post and church on the Peace River, left Montreal in 1802. The party included one Father St. John. It is thought that they did not make the trip the first year and possibly wintered at Fort Chipewyan, the largest and most popular wintering place at that time. In the spring of 1803 the party went on and set up the post on the Peace, building the Fort and the church in the summer of that year. These facts are borne out by the church records in Montreal' [Peace River Block News, August 17, 1961]. A plan and sketches for a one-storey church building accompanied the letter from Montreal. Old Fort St. John clearly showed that it had been such a one-storey building, torn down and reconstructed later with an added second storey, along with a chapel. The date, carved in Roman numerals on the door post, was 1813. In 1806, when the first Fort was constructed, it was called Rocky Mountain Fort, and in 1805 it was referred to by the trader at Dunvegan as 'Rocky Mountain

Fort'. Perhaps the old church was still known by the older name, and perhaps also, like other Peace Country Posts, it was moved when it was rebuilt. However it happened, it seems that a certain Father St. John was the first priest." (Calverley 1999d)

- **1867 –** "Bishop Faraud, OMI, at present is locally recognized as the first to visit Fort St. John's Beavers in 1867. As a Bishop, his first concern would be to inspect parishes already established, therefore one may ask, 'Was there a church at Fort St. John in 1867? If so, was it called 'St. John's' after that first-comer in 1803? Or was it the rebuilt church of 1813?' If so, it may have been located at a Fort that nobody talks about these days. Fort l'Epinette, likely near the mouth of the present Pine River near Taylor." (Calverley 1999d)
- **1890 –** "It was not until 1890 that a recognized mission was built on the flat below present-day Fort St. John by Father Husson. . . . This may have been and probably was the Old Fort St. John burned down in 1973, or it may have been an older church, moved upriver from one of the Fort St. John's or Fort l'Epinette. A building once consecrated to the Church tends to be cherished and restored where possible." (Calverley 1999d)
- **1913 –** "Joe Gilmette -- French homesteader, took land across river, about 1913. Cleared land and worked only in Stanfield underwear and bare feet." (Calverley 1999q)
- **1916 –** "Fort St. John, an old Hudson's Bay post, is situated on Peace River Tp. 83 in this township. The only business carried on here is fur-trading." (Department of the Interior 1916h: 243)
- **1916 –** "One squatter was found on a small flat which occupies part of Sections 27, 28, 33 and 32." (Department of the Interior 1916h: 248)
- **1919 –** "In 1919 Vern McLean built his ranch house on the banks of the North Pine or Beatton. . . . Another year disease was introduced by unlucky chance and eventually Mr. McLean withdrew to his homestead near Fort St. John." (Calverley 1999n)
- **1921 –** "Mr. Finch started the first store on the hill at the present site as early as 1921. This was followed by several others until in 1923 the Hudson Bay abandoned the post by the river and moved to the site at Fish Creek, the Indian Reserve being north of this." (Bowes 1930)
- **1928 –** "HBC Factor Francis Work Beatton moved the fort to Fish Creek [Stoddart Creek] to be closer to homesteaders." (Pettit 2008:62)
- **1891 - 1929 –** "At Fort St. John there are two well-stocked stores, Revillon Freres and the Hudson's Bay Company. The headquarters of the Provincial Police are also located here. It is expected that the Dominion Government Telegraph Line will be completed to St. John this year and will shortly be extended to Hudson's Hope. The land in the vicinity of St. John, and particularly on the plateau to the north, is being rapidly taken up. There are fifty or sixty settlers already on the ground, several of whom last summer, besides growing the ordinary vegetables, ripened patches of wheat and barley." (Canada Department of Lands 1929)

For the Fort St. John locality, there are four historical sites in the LAA recorded in the Provincial Heritage Register. These sites are HbRf-8 (rock cairn), HbRf-29 (cultural depressions), HbRf-31 (Rocky Mountain Fort – Yale's House – MacIntosh's House), and HbRf-37 (homestead).

6.2.1.2 Historical Sites – Provincial and National

A search of local, regional, provincial, and national heritage databases, as well as local government online meeting minutes (City of Fort St. John 2010) and official community plans (District of Hudson's Hope 2005; City of Fort St. John 2010) was conducted to determine which, if any, historical sites within, or adjacent to, the LAA have been formally recognized for their heritage value.

The two largest communities associated with the LAA, the City of Fort St. John and the District of Hudson's Hope, have acknowledged the importance of heritage and historical sites in their official community plans (OCP) (District of Hudson's Hope 2005; City of Fort St. John 2010). As part of the OCP for the District of Hudson's Hope, a plan showing known historical sites was compiled, though not included in the publically available OCP. The OCP for the District includes a recommendation that a heritage program be implemented to inventory Hudson's Hope's heritage resources, which the District defines as "buildings, structures, sites, landscape features, traditions, stories, names, artwork and utilitarian objects" (District of Hudson's Hope 2005:48).

At the regional level, Bylaw No. 1105 was established by the Peace River Regional District in 1997 under the terms of the British Columbia *Local Government Act*, which provides for services related to Heritage Conservation within the Peace River Regional District (PRRD; Peace River Regional District 2009). Under this legislation, a community Heritage Register function has been enabled, although sites have not been added to the Provincial Heritage Register. Of the six sites on, or recommended for, the Register, two sites are adjacent to the LAA. The two sites are the Hudson's Bay Company Cemetery at Old Fort [St. John], adjacent to the former Roman Catholic Mission (Peace River Regional District 2009a), and the Alaska Highway. There has been recent discussion at the municipal and regional level to seek heritage designation of this site at the national level (City of Fort St. John 2010; Peace River Regional District 2010a). The four other sites, recommended for the Register, are located some distance from the LAA.

In addition, the PRRD recommended that a new Heritage Services Bylaw be developed to establish a Regional Heritage Services function (Peace River Regional District 2010a, 2010b). Among other conditions, this bylaw will require that commissioners be appointed to a newly-established Heritage Advisory Commission and that regional inventories or prospective historical sites be identified (Peace River Regional District 2010a).

At the provincial and national level, a number of historical sites have been recorded in the Provincial and National Heritage Registers. These sites are discussed in more detail below.

6.2.1.2.1 Historical Sites Recorded as Provincial or Local Heritage Sites

A review of historical sites recorded within the LAA was conducted, based on those sites listed in the Provincial Heritage Register (Figure 6.1). This review builds on the summary of recorded historical sites provided in the Site C Gap Analysis study (Arcas 2009).

Resources examined for this study include available original site records (handwritten or typed site inventory forms and associated sketch maps) on file with the BC Archaeology Branch, a recent summary of site data for the LAA (Hutchcroft 2009), and reports prepared by archaeological consultants. Analysis included a comparison of recorded historical site locations with historical maps.

As noted in the gap analysis report (Arcas 2009), the historical sites were identified during archaeological studies, and consist primarily of archaeological sites that are historic in age, or that contain historical components (Arcas 2009:44). However, in some cases, the recorded sites do not contain any archaeological components, but are solely of historical attribution (e.g., a log cabin).

Twenty-five historical sites have been recorded within the LAA (Figures 6.1, 6.5). Of these, one is classified as a burial location, two are historical fur trade fort locations, 14 consist of historical buildings, two contain historical features, and the remaining seven contain historical artifacts. Eighteen of the historical sites are located north of the Peace River, and the remaining seven are south of the river.

HbRh-2 is a possible post-contact [redacted] located on the west bank of Cache Creek. The provincial site record does not indicate that the site is historical. However, the first report of this location in 1954 describes the site as an “Indian burial (Christian).” A description of this site and report of a recent visit to the site location is found in Cowie (2009:18-20) and Appendix F.

Two fur trade fort sites are recorded in the LAA. HaRl-4 is attributed to Rocky Mountain Portage House, and was recorded in 1973 near Hudson’s Hope (Fladmark 1975). The site represents the original location of Rocky Mountain Portage House. Stone artifacts are present as well. The site record describes disturbance to the site from construction of a ferry landing. The reported trail to Rene Lake and Moberly Lake may have been located near this site.

HbRf-31 is the site of Rocky Mountain Fort, Yale’s House and MacIntosh’s Post (Burley, et al. 1996; Arcas 2009:45), and was recorded in 1975. The site is located on the south bank of the Peace River, southwest of Fort St. John and northwest of the Peace – Moberly confluence. Archaeological excavations at this site in the 1970s and 1980s are well documented (Arcas 2009; Burley, et al. 1996).

Historical structures are associated with 14 historical sites in the LAA, including HaRj-23, HaRk-9, HaRk-10, HaRk-13, HaRk-16, HaRk-29, HaRk-32, HaRk-33, HaRk-34, HaRk-38, HbRf-37, HbRg-28, HbRh-60, and HbRh-61. The historical structures include log cabins, barns, bunkhouses, a school, a blacksmith shop, chicken houses, sheds, cellar depressions, and corrals. For structures for which a date or approximate time period could be determined, the relative ages of these structures range from the late 1800s to the mid-1900s. A brief summary of each site follows:

- HaRj-23: This site consists of a log cabin (ca. 1920) recorded in 1976 and known as the ”Moody Homestead,” although recent information suggests that it may have been built and occupied by a Charlie Townsend. It is located north of the Peace River, approximately midway between Farrell Creek and Halfway River. Historical maps (Department of the Interior 1928) identify structures in the general vicinity of this cabin. In 1976, the building was recorded as intact, but dilapidated.
- HaRk-9: This site consists of four cultural depressions, a cabin, historical refuse, and a possible corral dating to the 20th Century, and was recorded in 1977. The site is located northeast of Lynx Creek on the south bank of the Peace River.
- HaRk-10: This site consists of a cabin, bunkhouse, and shed dating to the 20th Century and known as ”Rutledge’s Cabin” (Figure 6.6.18) The site is located west of Farrell Creek on the north bank of the Peace River. On the Department of the Interior (1928) map, a building is noted in the general location of this site.

The Canada Department of Lands (1945) map shows a school in the same locality. On the 1977 site form, the buildings are reported as being in excellent condition and of extremely good workmanship.

- HaRk-13: This site consists of a cabin which, in 1977, was described as one of the oldest cabins still standing in the region. The site is located on the west bank of Farrell Creek, north of its confluence with the Peace River. A building is noted on the Department of the Interior (1928) map in this general location.
- HaRk-16: This site, located east of Farrell Creek and on the north bank of the Peace River, was originally recorded in 1977 and then consisted of a surface lithic scatter and former cabin that had been "plowed under." The site is presently situated in a plowed field, and remaining archaeological and historical materials may still be present, in a disturbed state.
- HaRk-29: This site is known as the "Beatty Homestead" and is located west of Farrell Creek on the north bank of the Peace River. It was originally recorded in 1977 and then consisted of a barn, chicken house, and shed dating to approximately 1920.
- HaRk-32: This site is known as "Forsythe's Homestead" and was recorded in 1977. The site is located on the west bank of Farrell Creek and north of its confluence with the Peace River. The site consists of one log cabin. A building is noted in the general location of this site on the Department of the Interior (1928) map.
- HaRk-33: This site, known as the "Robinson Homestead," is located approximately midway between Farrell Creek and Lynx Creek on the north bank of the Peace River. The site was recorded in 1977 as a log cabin (ca. 1920's) and a log shed.
- HaRk-34: This site is known as "Henry Farrell's Cabin" (ca. 1900 to 1915) and was recorded in 1977. The site consists of a log cabin on the east bank of Farrell Creek at its confluence with the Peace River. A building is shown in the general location of this site on the Department of the Interior (1928) map. In 1977, the cabin was reported as having a large rock through the roof.
- HaRk-38: This site consists of a log cabin and was reported to be "dilapidated" on the 1977 site form. The cabin is located east of Farrell Creek north of the Peace River.
- HbRf-37: This site was recorded in 1974, and was reported to consist of log buildings including a cabin, barn, and cellar.
- HbRg-28: This site, known as the "Flatt – Freer Homestead," was recorded in 1977, and consists of three historical buildings (one two-storey log house, one small bunkhouse and one barn) dating to the 1920s. The site is located on the north bank of the Peace River, southeast of the mouth of Wilder Creek. The Department of the Interior (1928) map identifies buildings in the vicinity of this site.
- HbRh-60: This site, known as the "Dopp Homestead," was recorded in 1977 and is located on the east bank of Cache Creek (Figure 6.6.37). The site consisted of several log structures and barns dating to the 1920s and 1930s, and includes the original Bear Flat School House (1921). The latter structure has since been relocated. A building is recorded on the Department of the Interior (1928) map, a school is indicated on the Canada Department of Lands (1931) map, and a post office is noted on the Canada Department of Lands (1936) map.
- HbRh-61: This site, known as the "Watson Homestead," was recorded in 1977 and is located north of the Peace River beside an unnamed creek. Two log buildings, including a cabin and a bunkhouse (ca. 1944) were recorded.

Two recorded sites in the LAA consist of historical features. HaRl-28 is a canoe skid (i.e., a location on the shoreline used as a canoe landing, in which cobbles have been cleared away and a linear feature remains) that is Pre-contact or from the fur-trade period. The site is located southwest of Hudson's Hope.

HaRl-5 consists of a historical structure (conical tents), a transportation feature (trail), and a traditional use site (cultural landform). The camp site was in use in 1931 and is reported to be on the trail between Hudson's Hope and Moberly Lake (Murton 1973:17). The cultural landform, consisting of a ceremonial boulder, was reported to be approximately 400 m south of the camp site and adjacent to Maurice Creek. The recorded location of the site adjacent to the trail from Hudson's Hope to Moberly Lake corresponds to the general location of the trail identified on historical maps.

The remaining sites consist of historical cultural depressions (HbRf-8, HbRh-45, HbRj-10), or historical glass, ceramic, metal or iron artifacts (HbRi-10, HbRj-6), or both historical cultural depressions and artifacts (HbRh-35).

6.2.1.2.2 Peace River – Provincial Heritage River

The LAA is bisected by the Peace River. The Peace River has an ancient history of human use and has been integral to many aspects of settlement and interactions with the environment, developing economies (e.g., hunting and gathering, extraction and production, trade and commerce, transportation and communication, technology and engineering), and building social and community life in the Peace River region.

In 1998, the Peace River was recognized as a provincial heritage river by British Columbia's Heritage River Program (B.C. Ministry of Environment 2010; Province of B.C. 1998). It has been recognized, specifically, as a working river that "integrates economic activities with natural heritage, recreational, historic, and traditional cultural values" (B.C. Ministry of Environment 1998). The Province's vision statement seeks to manage resource-based uses of the river while maintaining representative natural heritage qualities and recognizing the historical heritage values of the river corridor to First Nations and non-Aboriginal people (Province of B.C. 1998).

6.2.1.2.3 Historical Sites Recorded on the National Register

One historical site, located just outside of the LAA, has received recognition at the national level. The NWC fur trade post of Fort St. John (i.e., Fort D'Epinette [1806 to 1823]), at the confluence of the Beatton and Peace rivers, was designated as a National Historic Site in 1958 (Parks Canada 2005). A National Historic Site is defined as a place of profound national importance, since it bears witness to Canada's defining moments and illustrates the country's human creativity and cultural traditions. Each National Historic Site contributes a sense of time, identity, and place to our understanding of Canada as a whole (Parks Canada 2008). This former fort location is within Beatton River Provincial Park. There is no federal designation or recognition for the other fur trade post locations that are situated along the Peace River in British Columbia, or for any of the other heritage sites within the LAA.

6.2.1.2.4 Peace River – A Cultural Landscape

In a broader context, the cultural landscape of the Peace River region, comprised of the river valley and its associated uplands, is also noted. Parks Canada (2010:253) defines cultural landscapes as "any geographical

area that has been modified, influenced, or given special cultural meaning by people." In this context, the Peace River region is both a cultural landscape and a rural historical landscape.

6.2.2 Historical Resources Overview Assessment

As noted in Section 6.1.2, a historical resources overview assessment was completed for project components in which development plans are not finalized. The historical overview of reviewed background data for each area, including the Provincial Heritage Register, historical literature, aerial photographs, information provided by stakeholders, local residents, and others to determine if there are known historical sites or the potential for historical sites in these areas of the LAA. The results of the overview are provided below. The archaeological overview assessment of this report (Section 5.2.3) provides a detailed summary of each development area, including size and location.

6.2.2.1 As Yet Undefined Construction Activity Areas near the Dam Site

A review of the Provincial Heritage Register indicates there is one previously recorded archaeological site in the as yet undefined construction activity areas near the dam site that has a historical component. As noted in Section 5.2.3, one artifact, a grey gunflint, was identified at archaeological site HbRf-43. Two recorded historical sites, HbRf-23 (John Beatton's homestead; the site record includes one 1895 farmhouse) and HbRf-34 (Frank Beatton's homestead; a former HBC Factor) are located outside, but in the vicinity of the as yet undefined construction activity areas near the dam site. No other known historical sites are located in the unsurveyed portions of the development area.

The potential for unrecorded historical sites in the as yet undefined construction activity areas near the dam site is considered to be moderate.

6.2.2.2 Wuthrich Quarry

There are no previously recorded historical sites in this project component. The potential for unrecorded historical sites is considered low.

6.2.2.3 West Pine Quarry

There are no previously recorded historical sites in this project component. The potential for unrecorded historical sites is considered low.

6.2.2.4 Portage Mountain

There are no previously recorded historical sites in this project component. As noted in the archaeological overview assessment of this report (Section 5.2.3), this component is characterized by exposed bedrock outcrops, sheer cliffs, and steeply sloping terrain. During this study, the Golder team was informed that there is a historical mine and cabins situated within the Portage Mountain Quarry. This location is in the vicinity of the

historical Gething coal mining claim; the reported historical features are likely associated with this claim. The "Hudson's Hope Steam Vents," a natural landscape feature of heritage significance is located in the vicinity of Portage Mountain, but it falls outside of the LAA.

Given that historical features have been observed in the Portage Mountain Quarry, the potential for historical sites is considered high.

6.2.2.5 Del Rio Pit

There are no previously recorded historical sites in this project component. The potential for unrecorded historical sites is considered low.

6.2.2.6 Area E

There are no previously recorded historical sites in this project component. The potential for unrecorded historical sites is considered low.

6.2.2.7 Recommendations

If activities within the as yet undefined construction activity areas near the dam site are proposed in the vicinity of HbRf-43, it is recommended that an assessment of this site be conducted. It is also recommended that an assessment of the Portage Mountain Quarry be conducted since the potential for historical sites in this project component is considered high. These locations will be addressed in a manner consistent with the current heritage assessment as development plans are finalized or access is obtained, prior to land-altering activities in those areas.

6.2.3 Stakeholder Interviews

Interviews with stakeholders were carried out to better understand what historical resources are valued within the LAA and why they are important. Stakeholders included (1) local and regional historical societies, museums, an archives committee, and a committee dedicated to documenting locations of local cemeteries; and (2) local residents and property owners in the LAA, as well as individuals with specialized knowledge about the LAA. Thirty-eight stakeholders were invited to participate in interviews, and 22 were interviewed. Six of the in-person interviews included subsequent site visits with the interviewees. A summary of the results from interviews with local and regional historical societies, museums, and other organizations is below, followed by interview results from local residents, property owners, and individuals.

6.2.3.1 Interview Results – Historical Societies, Museums, and Committees

A total of 17 stakeholders consisting of local and regional historical societies, museums, and other organizations with a potential interest in the historical sites and heritage values of the LAA were identified. Of these, ten opted to participate in an interview, of which eight provided direct responses and two provided information after

meeting with their committees. Of the remaining seven stakeholders, three were provided the questionnaire by mail but no response was received, and four others declined to participate. In addition to the group responses received, one individual provided a response that was not intended to be considered representative of the group as a whole. The heritage questionnaire prepared for historical groups and organization is provided in Appendix K.

A summary of the questions and the results of the interviews received follows. Where duplicate themes, ideas, or places have been identified, the responses have been grouped and compiled. Where more detailed or site-specific verbal or written responses were provided, those responses have been reproduced verbatim below. Several locations identified during these interviews are outside of the LAA; they have been included in the section below. The themes, ideas, and places provided by local and regional historical societies, museums, and committees are comparable to those concepts and locations provided by local residents and other individuals.

6.2.3.1.1 Summary of Interview Results

Local and regional stakeholders were asked to identify words, ideas, or themes that describe the historical identity of the Peace River valley, specifically in, and adjacent to, the LAA. Identifying historic themes in a region enables a community to articulate its unique heritage values and identify historical resources based on these values. In conjunction with the BC Archaeology Branch Checklist of Criteria for Post-Contact Site Evaluation (*British Columbia Archaeological Impact Assessment Guidelines* [1998], Appendix E), these values contributes to the assessment of significance of historical sites within the LAA.

The information in the subsections below is derived from the interviews. Where required, points of clarification have been added. The subsections describe (1) the words and ideas identified, (2) historical themes, (3) heritage sites and places, (4) locations considered priority for further research, (5) mitigation suggestions for historical sites, and (6) general comments. Stakeholder values and ideas of heritage are expressed throughout the subsections.

The following words or ideas were identified by the stakeholders. These terms capture the historical identity of the Peace River valley in the vicinity of the LAA, and contribute to the historical themes pertinent to the LAA. The order represents a weighted ranking based on importance and frequency as provided by the respondents.

- Historic transportation corridor
- Natural, picturesque
- Fur trade
- Settlement – farming
- Pre-contact peoples
- Early explorers
- Wildlife habitat, corridor, breeding ground
- Tourism
- First Nations

- Gold rush
- Recreation
- Trappers
- Unpopulated
- Palaeontology
- Local culture
- Spirituality

From the words and ideas identified by stakeholders in the surveys, several themes emerged. These themes are representative of those in Parks Canada's (2009) National Historic Sites of Canada System Plan, namely:

- Developing Economies
- Inhabiting the Land
- Natural Environment
- Local Culture
- Social and Community Life
- Local Government

A number of heritage places and sites were identified by stakeholders in, and adjacent to, the LAA:

- Trappers' cabins; North Peace area will have more trappers' cabins
- Homesteads; homesteads just off the road
- First Nation burial sites
- Settlers' family cemeteries
- Farming sites
- Fur trade sites (Rocky Mountain Fort near the confluence of Peace River and Moberly River – Fort from 1794 to 1805; Fort St. John – fur trading fort from 1860 to 1925 [south side of Peace River across from lookout at end of 100th Street], adjacent to Site C Project; Fort St. John – fur trading fort from 1872 to 1925 [down Old Fort Road], adjacent to Site C Project; Rocky Mountain Portage House and Hudson's Bay Company Post, Hudson's Hope); no buildings left at these sites
- Hudson's Bay Company Cemetery, Fort St. John
- Alaska Highway
- St. Peter's Church, Hudson's Hope
- Hudson's Hope Museum

- Gething House, Hudson's Hope
- Pioneer Cemetery, Hudson's Hope
- Ferry landing, Hudson's Hope (see below)
- Old town site, Hudson's Hope (see below)
- Hudson's Hope is in itself a historic place with a lot of historical background that cannot be explained in one sentence, so the following will explain.
  - The Peace River was navigable below Hudson's Hope but since the melting of the last ice when the Peace River canyon was formed above Hudson's Hope, the canyon was too treacherous to navigate. This necessitated a portage trail around the canyon to the upper regions of the Peace. This trail, known as "the Rocky Mountain portage trail," is still visible in a few areas, where it leaves the river below the town, and where it climbs up the hill to the top flats
  - Where the portage trail leaves the river is the historic landing site of the paddle wheelers and supply boats that plied the Peace prior to a road being built between Fort St. John and Hudson's Hope in the 1930s
  - As the head of navigation on the Peace, Hudson's Hope welcomed travelers, trappers, prospectors, surveyors, people looking for land to settle on, mining companies, fur traders and many politicians and big game hunters
  - Near Hudson's Hope there are tracks of prehistoric animals and there were many more sites that were flooded out by Williston and Dinosaur reservoirs
  - Another historical site in the Peace River Canyon is the "steam vents" that were first mentioned in Alexander Mackenzie's diary of his historic trip through here in 1793
  - Other sites of historical importance are the two landslide locations that blocked off the Peace River for several hours. The slide at Cache Creek on the east end of Bear Flat occurred in 1914 and the one above the Halfway River slide in 1973
  - Hudson's Hope was also famous for being the jumping off place for many hunting expeditions into the mountains and also because many outfitters made this area their home
- One barn, located on private property, was identified
- The river was the main corridor, so there wouldn't be well-worn trails along it
- No shipwreck location was identified during the interviews

Based on the types of heritage places or sites identified, representatives were asked which locations are considered priority for further research. The following responses were received:

- Peace River history itself
- One of the early forts, Fort d'Epinette, was 500 yards downstream of the mouth of the Beaton River on the north bank of the Peace
- Hudson's Bay Company cemetery, Fort St. John, within the Old Fort area, could be affected by the Project
- The Alaska Highway
- There is a painting by George Hunter that depicts a native burial ground along the river; a copy of the painting is in the Hudson Hope Museum
- This may have been a corridor for Palaeo-Indians; there may be very early sites here
- First Nations sites; this would have been a high use area for Pre-contact peoples; can the stories that a lot of the farmers in the area have about sites that they haven't told others now be told?
- Family cemetery, Lynx Creek
- Family cemetery, Attachie
- Private burial, between Bear Flat and Fort St. John
- Big, beautiful barn built in the 1940s located on the Hudson's Hope Road should be moved before flooding
- Rocky Mountain Fort near junction of Peace River and Moberly River (1794 to 1805)
- Fort St. John, fur trading fort from 1860 to 1925, on the south side of Peace River across from lookout at the end of 100th Street
- Fort St. John, fur trading fort from 1872 to 1925, down Old Fort Road
- Rocky Mountain Portage House and Hudson's Bay Company Post, Hudson's Hope
- Burial site, Hudson's Hope
- Old cabin, Hudson's Hope
- We do not need any more studies, but what we do need are the finances to build a bigger museum building to display all the historical data and material that is available

Suggestions for mitigation or future interpretation of historical sites and locations within and near the LAA were provided by stakeholders:

- There is a lookout in Fort St. John at the end of 100th Street where you can see the valley and will see the dam; they are working on putting a parking lot and such there; it would be a good place to put interpretive panels and highlight the history of the area
- There is, or was, also a rest stop where some information was wanted; any rest stop or recreation sites would be good places to have interpretive signage
- Will there be an interpretation centre with the dam? There could be some historical information (signage, interpretation) there as well

- The Cemetery Seekers are a group that look for burials and cemeteries and maintain a database to that end; funding for theirs and other groups doing heritage work in the area would be greatly appreciated
- Move the old barn
- Historic buildings should be moved to a proper place if they are to be flooded
- Document where the archaeological sites are and if possible, excavate them
- It might be better to leave graveyards where they are; what would be the point of moving them as long as the bodies are guaranteed to be intact; cement pad over top perhaps
- The historical [Hudson's Hope] "Ferry Landing" and "Portage Trail" need to be preserved
- Better access and safety railing is needed for the [Hudson's Hope] "Steam Vents"

General comments from stakeholders about the historical resources in, and adjacent to, the LAA included:

- The historic site of Rocky Mountain Fort, the first of many forts in this region, will be flooded. Much of Alexander Mackenzie's route by water and land to the Pacific in 1793 will be flooded. The damming of the Peace River yet again, a river which has Federal Heritage Status, would be a big loss. No longer will the river that was a highway for the fur trade for over a century, a highway for transportation for First Nations, a highway for all the steamboats that brought settlers here in the early to mid-1900s, be in a condition even similar to the historic role it once played
- This is a designated heritage river with significant history and heritage attached to it and it is inappropriate for it to be flooded
- There are too many historical resources along the river. We don't know how many native burials are along the river, but there are liable to be many burials
- When the W.A.C. Bennett dam was built, there were at least two burials that were left under water. This is a situation that is not desired for this new dam

6.2.3.2 Interview Results – Local Residents and Other Individuals

A total of 20 individuals or families were initially identified as potential interviewees based on previous information provided regarding heritage sites and locations of heritage value. Of these, 13 interviews were conducted, four individuals declined to participate stating that they had no specific information to provide regarding heritage sites, two declined to participate for personal reasons, and one was not interviewed but instead directed the Golder team to two other individuals who would have more pertinent information to provide. These two other individuals were already identified in the initial group of 20.

A total of 13 interviews were conducted with long-established residents of the LAA or their relatives. Interviewees were provided with a written copy of the heritage resources questionnaire (Appendix K), and associated topographic and orthographic maps. Ten of the interviews with property owners and lessees were conducted in-person at their residence, with subsequent site visits conducted with six of these interviewees. One interview with a local resident was conducted over the telephone. Two interviews with individuals whose families were former residents of the LAA were conducted in Fort St. John and Vancouver, respectively.

6.2.3.2.1 Summary of Interview Results

Local residents and their relatives discussed their connection to, and history with, the Peace River region. Sites or locations of heritage significance were identified and discussed. The types of places are summarized below:

- Pack trail – wagon road from Fort St. John to Hudson's Hope
- RCMP – NWMP trail to the Klondike
- Fur trade forts
- Early homesteads, structures, barns, cabins
- Known burial – cemetery locations
- Transportation along the Peace River
- River crossings – fords – ferry landings
- Early bridges across tributaries of the Peace River
- Coal mines
- Lime kilns
- Trappers' cabins and trap lines
- Early rodeo grounds
- First Nations camp sites and locations where buried pemmican was encountered during farming activities
- Fossils
- The "Gates"
- Hudson's Bay Company Factor house(s)
- Springs, "water wheels," waterfalls
- Natural features (i.e., a large boulder) identified as having spiritual significance
- Historical gardens and plantings

Based on the interviews and subsequent field visits, several locations or sites were confirmed to fall within the LAA, including two family cemeteries, sections of trails, and the wagon road (reported to closely follow the current location of Highway 29), and early homesteads and cabins. See Appendix J for a description of the historical sites within the LAA.

The location of a reported burial(s) within the LAA could not be confirmed since permission to access private property was not granted for the field program. This location will be assessed in a manner consistent with the current heritage assessment prior to construction once access permission has been obtained.

Several locations were confirmed to fall outside the LAA, specifically:

- One known [redacted] location and associated homestead in Section 33, Township 83, Range 20
- HaRk-31 (Zelinka homestead)
- Hudson's Hope HBC Factor house
- Portions of the pack trail or wagon road from Fort St. John to Hudson's Hope, as well as the wagon road to the Klondike
- A distinct barn, approximately 70 years old, and associated structures

Interviewees provided general comments and ideas about the heritage resources in the LAA. The information below was transcribed directly from, or paraphrases, the comments expressed during the interviews. Where required, points of clarification have been added.

- Sites that can be moved should be moved
- Provide interpretation – install plaques at strategic locations
- Move the old Bear Flat school house to a historic park
- Create an interpretation and historic site for Bear Flat
- If graves can stay where they are, then leave them
- Don't build through or near gravesites; building near will lead to damage and vandalism
- It's good that there's a historical record [the 1970s SFU photographs and notes] of places that aren't there anymore
- Need to locate and document places using a GPS, and correct the information from the 1970s if it's wrong
- The old garden sites need to be identified
- The archaeological sites are all significant
- Interpret and add some formal trails heading to the waterfall at Maurice Creek
- Rocky Mountain Portage House – there are few structures present, and there is varying interpretations regarding its significance
- Rocky Mountain portage trail is of interest to the community; part will disappear due to the Project, this needs to be addressed
- Could a hiking trail be established on top of the Hudson's Hope berm [shoreline protection] and incorporate the Rocky Mountain portage trail in it?

- Dudley Shaw's cabin is of interest to the community; although it may not be directly impacted, part of the park will be and will require modifications. The cabin should be considered during discussions of significance
- The whole valley is important. It all has the same value. It's all part of a whole. How can you get across the value of the valley to anyone who doesn't live here? It's very hard

6.2.4 Field Investigations

As outlined in the historical approach and methods (Section 6.1.4), field investigations included an inventory and assessment of known (i.e., previously recorded) historical sites and potential (i.e., reported but not recorded) historical site locations within the LAA (Figure 6.1).

The field inventory included examination of standing historical structures, surface and subsurface inspections, and assessment of historical sites. A total of 50 locations were examined from the area south of Fort St. John to west of Hudson's Hope. As noted in Section 6.1.4, the historical field crew relied on background information and data provided by stakeholders and the Golder team to identify locations for investigation. A visual survey of known or potential historical site locations was conducted. Standing structures or features, if present, were examined and recorded. A total of 184 subsurface tests were excavated during the historical field assessment, with 176 of these tests excavated within recorded site locations. The remaining nine tests excavated at two locations contributed to the determination that these locations did not contain historical sites.

A total of 42 sites were recorded within the LAA, including 25 previously recorded historical sites and 17 newly recorded historical site locations (Figures 6.1, 6.5, 6.6.1 to 6.6.42). A total of 862 artifacts were collected. Of the sites recorded, 28 are located north of the Peace River, 12 are located on the south side, and components of two sites are situated both north and south of the river. In terms of project components, two sites are in the dam site, two sites are located in both the dam site and reservoir, 31 sites occur in the reservoir, including 7 sites between the maximum full pool and the five year beach line, four sites are in the highway realignment, and three sites are located in both the highway realignment and reservoir.

The 42 identified sites consist of Rocky Mountain Fort, Rocky Mountain Portage House, Rocky Mountain Portage Trail, former homesteads or other habitation sites including collapsed or partially standing structures, industrial or agricultural sites and associated artifacts, a wagon road, two trails, two unregistered cemeteries, a ferry landing, a canoe skid (a location on the shoreline used as a canoe landing, in which cobbles have been cleared away and a linear feature remains), a wagon wheel, and physiographic landscape features.

During the field investigation, site HbRf-31 (Rocky Mountain Fort) was revisited and general site observations were made. No assessment work was conducted as part of this program as extensive excavations have been previously completed at the site. Permission to access six other sites on private property, including HaRl-4 (Rocky Mountain Portage House) was not granted for the field program.

6.2.5 Erosion Potential Assessment

A total of 27 historical sites were evaluated and ranked using E-PAST. The sites received scores between zero and 48. Of the 27 sites evaluated, 16 were classified with Low erosion potential, 4 were classified with Moderate erosion potential, and 7 were classified with High erosion potential. E-PAST site rankings will be used in the development of site-specific mitigation strategies (see Volume 4 Section 32.3.4 Summary of Proposed Heritage Resources Mitigation). Rankings and E-PAST worksheets for each site are in Appendices M-1 and M-2.

7.0 HERITAGE RESOURCE EVALUATION

An important step in assessing project effects on heritage resources involves evaluating the heritage significance, or "value," of individual heritage sites. The following sections discuss the methods and results of the heritage resource evaluation. The methods used to evaluate heritage significance differ for palaeontological, archaeological, and historical sites, and therefore they are discussed separately in Sections 4.1, 5.1, and 6.1. In all cases it is important to understand that the concept of "heritage significance" is discipline specific and different from the assessment of the significance of residual effects, as detailed in Volume 4 Section 32.4.2.1 Assessing Significance of Residual Effects on Palaeontological Sites, Section 32.4.2.2 Assessing Significance of Residual Effects on Archaeological Sites, and Section 32.4.2.3 Assessing Significance of Residual Effects on Historical Sites.

7.1 Palaeontological Site Evaluation

As indicated in Section 4.1.4.1 above, positive palaeontological sensitivity areas were evaluated in accordance with criteria and weighting proposed in the *British Columbia Fossil Management Framework* (2004) to determine an overall significance score. The resulting ranking of palaeontological sensitivity areas provides a systematic method to formulate mitigation recommendations that reflect the relative importance of these locations. Table 7.1 summarizes the results of the palaeontological significance assessment.

The significance assessment was conducted after select palaeontological sensitivity areas were merged due to similarities in their contents and proximity to one another. Merging select locations resulted in a reduction in the total number of positive palaeontological sensitivity areas.

Table 7.1: Summary of significance ratings for positive palaeontological sensitivity areas

Overall Significance Rating (Class)	Number of Sites	Palaeontological Sensitivity Area
Class I (Highest Palaeontological Significance)	26	PS013E, PS013F, PS025E, PS026C, PS026D, PS027J, PS027K, PS028B, PS029E, PSX07A, PS040D, PS042A, PS046B-C, PS048B, PS049B, PS049C, PS051B-C, PS053A-D, PS056A-B, PS093A-C, PS099A-C, PS119D, PS120D, PS121D, PS122B, PS123C
Class II (Moderate Palaeontological Significance)	113	PSND01I, PS001A, PS124D, PS001C, PS003B-D, PS004A, PS004D, PS005B, PS005C, PS005D, PS005E-F, PS006A, PS006C, PS012A, PS012C, PS012C/A, PS012D, PS012E, PS012H, PS013C, PS013D, PS013G, PS015A, PS017D, PS018A, PS021E, PS021F, PS023A, PS023B, PS025B, PS026A, PS026F, PS026G, PS027A, PS027F, PS027G, PS027H, PS027I/J, PS028A, PS029A, PS029B, PS029C, PS029D, PS029E/F, PSX07B, PS037B, PS043C, PS045A-E, PS047A, PS048A, PS050A, PS052A-D, PS057D, PS062A, PS062B, PS062D, PS063A, PS064A, PS064B, PS064C, PS065A, PS067A, PS069A-C, PS069D, PS069E, PS070A, PS070B, PS070C, PS070D, PS072B, PS072C, PS073D, PS073F, PS073I, PS078G, PS079A, PS079E, PS079G, PS084A, PS086A, PS090A, PS100A-C, PS101A-G, PS110B, PS110E-F, PS111A, PS111B, PS114D, PS114E, PS114G, PS115A, PS115E, PS115F, PS116C/D, PS116E, PS116F, PS116G, PS117A, PS117E, PS117F, PS117G, PS117H, PS117I, PS118C, PS119B, PS119C, PS122A, PSR01H2, PSR05H, PSQ02A, PST01B, PST02E, PST03B
Class III (Lowest Palaeontological Significance)	34	PS002B, PS002C, PS012F, PS024B, PS029G, PS037A, PS038F, PS038G, PS043D, PS047B, PS061B, PS062C, PS062E, PS062F, PS062G, PS062L, PS062M/N, PS062N, PS064D, PS066E, PS067B, PS067C ,PS068C ,PS073B, PS073C, PS076E, PS077F, PS079H, PS080A, PS083B/C, PS098E, PST01E, PST04F, PST05G

In addition to the locations presented in Table 7.1, eleven positive palaeontological sensitivity areas were identified beyond the LAA. These locations were included in the individual significance assessments presented in Appendix E, but are not presented in Table 7.1, or included the effects assessment (Volume 4 Section 32.3 Effects Assessment) because there is no interaction with proposed Project components. As such, these eleven locations do not require application of mitigation strategies. However, it is important to note that three of these locations (PSX09Z, PSX09E, and PSX09G) represent vertebrate reptilian skeletal elements (e.g., dinosaur bones) and are considered to be of high scientific significance. The remaining eight locations (PSR01B2, PSR01B4, PSR01B7, PSR01B8, PSR01I3, PST12A, PSX13B, and PSX22Z) contain fossils similar to those found elsewhere in the LAA and are of moderate to low scientific significance.

7.2 Archaeological Site Evaluation

As indicated in Section 5.1.7 and Section 18.2.3 of the EIS Guidelines, archaeological sites were evaluated in accordance with provincial guidelines (BC Archaeology Branch 1998). All identified archaeological sites in the LAA have been assigned low ratings for public and economic significance. Based on discussions with Aboriginal groups, the ethnic significance of all sites is considered high.

Due to the uniformity of the evaluations for the public, economic, and ethnic significance criteria, the archaeological mitigation framework was based on an evaluation of scientific significance. To standardize the approach for evaluating scientific significance, a matrix was developed for tabulating critical attributes for each site. Consistent with the BC Archaeology Branch Guidelines (1998), the criteria used in the table relate to site complexity, integrity, preservation, uniqueness, and artifact abundance and diversity.

Table 7.2 summarizes the results of the significance evaluation, and Appendix I provides evaluations for each archaeological site in the LAA. Fourteen archaeological sites are rated as having high scientific significance, while 19 are rated as moderate to high. Scientific significance for 17 sites is considered to be moderate, and 28 are low to moderate. Of the evaluated sites, 137 were considered to be of low scientific significance. Twenty-six sites either were not accessible due to land access restrictions or had insufficient data to allow an assessment of scientific significance.

Table 7.2: Summary of scientific significance of Pre-contact archaeological sites

Scientific Significance Rating	Number of Sites	Borden Number
High	14	GlRj-2, HaRf-34, HaRk-1, HaRk-38, HaRk-46, HaRk-49, HbRf-62, HbRg-5, HbRg-6, HbRh-8, HbRh-16, HbRh-36, HbRh-66, HbRi-43
Moderate to high	19	HaRf-32, HaRj-14, HaRj-19, HaRj-32, HaRk-23, HbRf-61, HbRf-102, HbRf-115, HbRf-40, HbRg-47, HbRh-12, HbRh-122, HbRh-131, HbRh-33, HbRh-54, HbRh-55, HbRi-10, HbRi-41, HbRi-6
Moderate	17	HaRf-27, HaRj-23, HaRj-34, HaRk-50, HbRf-63, HbRf-65, HbRf-94, HbRg-49, HbRh-2, HbRh-6, HbRh-123, HbRh-130, HbRh-132, HbRh-136, HbRh-144, HbRh-145, HbRi-61
Low to moderate	28[a]	HaRf-25, HaRj-7, HaRj-27, HaRk-12, HaRk-15, HaRk-35, HaRk-55, HaRl-14, HaRl-29, HbRf-64, HbRf-93, HbRf-95, HbRf-99, HbRg-11, HbRg-50, HbRg-53, HbRh-20, HbRh-37, HbRh-57, HbRh-69, HbRh-104, HbRh-121, HbRh-124, HbRh-125, HbRh-146, HbRh-147, HbRi-57, HbRi-58

Scientific Significance Rating	Number of Sites	Borden Number
Low	137[b]	GlRk-5, HaRf-13, HaRf-24, HaRf-26, HaRf-28, HaRf-29, HaRf-30, HaRf-31, HaRf-33, HaRf-35, HaRf-36, HaRf-37, HaRf-38, HaRf-39, HaRf-40, HaRf-41, HaRg-3, HaRg-37, HaRg-38, HaRg-39, HaRg-40, HaRg-42, HaRh-15, HaRj-16, HaRj-17, HaRj-18, HaRj-21, HaRj-22, HaRj-26, HaRj-28, HaRj-29, HaRj-30, HaRj-31, HaRj-33, HaRj-35, HaRk-6, HaRk-8, HaRk-13, HaRk-16, HaRk-17, HaRk-43, HaRk-44, HaRk-47, HaRk-48, HaRk-51, HaRk-52, HaRk-53, HaRk-54, HaRl-10, HaRl-18, HaRl-19, HaRl-30, HaRl-31, HaRl-32, HaRl-33, HaRl-34, HaRl-35, HaRl-36, HaRl-37, HbRf-67, HbRf-88, HbRf-96, HbRf-97, HbRf-98, HbRf-100, HbRf-103, HbRf-104, HbRf-105, HbRf-106, HbRf-107, HbRf-108, HbRf-109, HbRf-110, HbRf-111, HbRf-112, HbRf-113, HbRf-114, HbRg-15, HbRg-17, HbRg-18, HbRg-46, HbRg-48, HbRg-51, HbRg-52, HbRg-54, HbRg-55, HbRg-56, HbRg-57, HbRg-61, HbRh-10, HbRh-18, HbRh-107, HbRh-112, HbRh-113, HbRh-114, HbRh-115, HbRh-116, HbRh-117, HbRh-120, HbRh-126, HbRh-127, HbRh-128, HbRh-129, HbRh-133, HbRh-134, HbRh-135, HbRh-137, HbRh-138, HbRh-139, HbRh-140, HbRh-141, HbRh-142, HbRh-143, HbRh-148, HbRh-29, HbRh-32, HbRh-34, HbRh-38, HbRh-42, HbRh-46, HbRh-52, HbRh-57, HbRh-63, HbRh-64, HbRh-65, HbRh-67, HbRh-68, HbRi-11, HbRi-12, HbRi-24, HbRi-25, HbRi-42, HbRi-46, HbRi-50, HbRi-56, HbRi-59, HbRi-60, HbRj-6
No access	14	HaRk-18, HaRk-25, HaRk-26, HaRk-36, HaRl-3, HaRl-4, HaRl-20, HaRl-21, HaRl-22, HaRl-23, HaRl-24, HbRf-32, HbRf-66, HbRh-19
Undetermined[c]	12	HaRj-15, HaRj-24, HaRk-2, HaRk-5, HbRf-42, HbRf-59, HbRf-60, HbRf-82, HbRh-53, HbRh-56, HbRh-58, HbRf-30

NOTES:
[a] Includes one site (HbRh-69) for which land access was not granted. A preliminary significance assessment is based on SFU studies.
[b] Includes four sites (HbRh-10, HbRh-18, HbRh-42, HbRh-68) for which land access was not granted. Preliminary significance assessments are based on SFU studies.
[c] Insufficient data available to assess scientific significance.

7.3 Historical Sites Evaluation

Table 7.3 summarizes the results of the significance evaluations for the 42 recorded historical sites. Based on the results, three sites are rated as having scientific significance, 30 are considered to have historical significance, six have public significance, and two have ethnic significance. Integrity and condition was considered good at eight sites, and poor at 30 sites. The significance of four previously recorded sites was not specified (NS) since permission to access HaRk-10, HaRl-5, and HbRh-60 was not granted for the field program, and the assessment of HaRl-28 was not completed due to high water conditions.

Table 7.3: Summary of significance of historical sites

Site Number	Scientific Significance	Historical Significance	Public Significance	Ethnic Significance	Economic Significance	Integrity and Condition
HaRj-23	Low	Yes	Low	Low	Low	Poor
HaRk-9	Low	Yes	Low	Low	Low	Poor
HaRk-10	NS	NS	NS	NS	NS	NS
HaRk-13	Low	Yes	Low	Low	Low	Poor
HaRk-16	Low	Yes	Low	Low	Low	Poor
HaRk-29	Low	Yes	Low	Low	Low	Poor

Site Number	Scientific Significance	Historical Significance	Public Significance	Ethnic Significance	Economic Significance	Integrity and Condition
HaRk-32	Low	Yes	Low	Low	Low	Poor
HaRk-33	Low	Yes	Low	Low	Low	Poor
HaRk-34	Low	Yes	Low	Low	Low	Poor
HaRk-38	Low	Yes	Low	Low	Low	Poor
HaRl-4	Yes	Yes	Yes	Low	Low	Poor
HaRl-5	NS	NS	NS	NS	NS	NS
HaRl-28	NS	NS	NS	NS	NS	NS
HbRf-8	Low	Yes	Low	Low	Low	Poor
HbRf-29	Low	Low	Low	Low	Low	Poor
HbRf-31	Yes	Yes	Yes	Low	Low	Good
HbRf-37	Low	Yes	Low	Low	Low	Poor
HbRg-28	Low	Yes	Low	Low	Low	Poor
HbRh-35	Low	Yes	Low	Low	Low	Poor
HbRh-45	Low	Yes	Low	Low	Low	Poor
HbRh-60	NS	NS	NS	NS	NS	NS
HbRh-61	Low	Yes	Low	Low	Low	Poor
HbRi-10	Low	Yes	Low	Low	Low	Poor
HbRj-10	Low	Low	Low	Low	Low	Poor
HbRj-6	Low	Low	Low	Low	Low	Poor
AMB-T1	Low	Low	Low	Low	Low	Poor
AMB-T3	Low	Yes	Low	Low	Low	Poor
AMB-T4	Low	Low	Low	Low	Low	Poor
AMB-T5	Low	Low	Low	Low	Low	Poor
AMB-T6	Low	Low	Low	Low	Low	Poor
AMB-12-1	Low	Yes	Low	Low	Low	Poor
AMB-12-2	Low	Low	Low	Low	Low	Poor
H-12-G4	Low	Yes	Low	Low	Low	Good
H-12-G9	Yes	Yes	Yes	Low	Low	Good
H-12-G10A	Low	Yes	Yes	Low	Low	Good
H-12-G10D	Low	Yes	Yes	Yes	Low	Good
H-12-G13-1	Low	Yes	Yes	Yes	Low	Good
H-12-G13-2	Low	Yes	Low	Low	Low	Good
H-12-G13-3	Low	Yes	Low	Low	Low	Poor

Site Number	Scientific Significance	Historical Significance	Public Significance	Ethnic Significance	Economic Significance	Integrity and Condition
H-12-G13-4	Low	Yes	Yes	Low	Low	Good
H-12-P1	Low	Yes	Low	Low	Low	Poor
AMB-12-4*	Low	Yes	Low	Low	Low	Poor

NOTES:
NS – not specified
* – described as GMY-12-1 in Volume 4, Section 32.3.3.3 Historical Resources

8.0 MITIGATION MEASURES – HERITAGE RESOURCES

Within the heritage resources LAA, 173 positive palaeontological sensitivity areas, 251 archaeological sites, and 42 historical sites have been recorded. Given that heritage sites are a non-renewable resource, site preservation and conservation are considered primary principles. Tables 32.3, 32.4, and 32.6 in Volume 4 Section 32.3.2 Heritage Resources outline potential mitigation strategies for heritage sites in the LAA. An expanded description of these potential heritage resource mitigation strategies is provided in Sections 8.1 to 8.5 below. The scope of mitigation for heritage resources will be determined through discussions with relevant parties, including the Royal British Columbia Museum, the British Columbia Ministry of Forests, Mines, and Lands (Land Tenures Branch), the BC Archaeology Branch, Aboriginal groups, the Business Practices and Consumer Protection Authority of British Columbia, museums, and local stakeholders.

8.1 Avoidance

The preferred means of limiting effects to heritage sites is complete avoidance. In certain circumstances, constraints such as terrain or design tolerances may make complete avoidance of a heritage site impossible. However, it may be possible to design some project components to reduce effects to a heritage site through avoidance or partial avoidance). Project components with the greatest opportunity for avoiding or partially avoiding heritage sites include the transmission line, Highway 29 realignment, access roads, and possibly the off-site quarries and construction materials areas. Given that detailed project design is ongoing, an opportunity exists to incorporate heritage resource considerations into this process and by, extension, to improve the likelihood that specific heritage sites can be avoided or partially avoided.

8.2 Effect Reduction or Minimization

For components of the Project where avoidance or partial avoidance of effects to heritage sites is not possible, steps may be taken to reduce or minimize effects to these sites (see BC Archaeology Branch 1998). The focus of these mitigation efforts should be on intact heritage resources, to the degree possible. Potential approaches to reduce or minimize project effects on heritage resources are described in the sections below.

8.2.1 Relocation

For historical structures, relocation is a mitigation option that is commonly requested by local community members, yet it can significantly affect heritage values (Bradshaw, et al. 2011). Relocating a heritage structure, for example, removes the building from its original context, reduces the potential for interpretation, and severs the connection to the wider social, cultural, historical, and natural settings. Heritage values of the historical structure or site are often strongly connected to the surrounding landscape, natural environment, and geographical setting. Relocation should only be considered an appropriate mitigative tool when it can be shown that heritage values will continue to be preserved after the relocation process has been completed. Consultation with the local community and appropriate regulatory bodies prior to relocation is important to address how the historical materials would be transported, who would be involved with the relocation process, what ceremonies (if any) should be performed and by who, and where the heritage structure should be relocated. After relocation, it is also recommended that the heritage structure continue to be monitored and managed (Parks Canada 2010). All steps and processes undertaken for the relocation of a heritage structure should be recorded in detail as part of the relocation process (Parks Canada 2010).

8.2.2 Capping

Site capping consists of placing a protective cover (e.g., sand, gravel, or lightweight fills such as closed-cell extruded polystyrene foam, etc.) on top of a heritage site as a means of protecting the deposits from disturbance, including erosion (Ardito 1994) and compaction (Davis, et al. 2004). In some instances (e.g., road building), the infrastructure may be built on top of the protective cap. While most commonly applied to archaeological sites, some buried historical sites and palaeontological sites could be protected by capping.

Capping of archaeological sites is considered by the British Columbia Archaeology Branch to be an appropriate mitigative measure when it can be demonstrated that important data will not be irrevocably lost through compaction, accelerated decomposition, horizontal displacement, or subtle changes in soil chemistry (BC Archaeology Branch 1998). Prior to the capping, geotechnical investigations may be required in order to select a suitable fill material. Furthermore, prior to capping, the British Columbia Archaeology Branch (1998) would likely require systematic data recovery (see Section 8.3) as compensation due to the inaccessibility of future investigations at the site. Such an investigation would require a *Heritage Conservation Act* S.14 Heritage Investigation permit. The scope of the systematic data recovery program would be proportional to the degree of effect on archaeological resources.

8.2.3 Structural Supports

Another possible mitigative measure involves the use of structural supports to elevate project components over a heritage site (see Davis, et al. 2004). While this approach could destroy heritage deposits within pile or footing locations, the impact could be offset by a data recovery program (i.e., excavation) within the impact area, and the preservation of adjacent areas of the site. Given the nature the Project, it is unlikely that there are opportunities for the use of structural supports as a site protection mitigation measure.

8.2.4 Inundated Structures

To mitigate the effects of inundation and to protect heritage sites from future erosion, certain strategies could be implemented that would help limit the adverse effects of wave energy and currents on heritage sites. A partial list of such conceptual strategies includes wave breaks (baffles) and groynes, which can be built as offshore structures, shore-normal and shore-parallel structures such as log-cribs, riprap blankets, and geotextile covers, and artificial reefs constructed out of suitable material (e.g., logs, geotextile, boulders, or rubble). The function of these structures is to break or attenuate incoming wave energy prior to reaching inundated and shoreline sites. Wave energy reduction limits the occurrence of erosion over the site surface. Wave breaks can be constructed as “walls” aligned parallel to a shoreline to protect areas near a shore or as “cells” to enclose a particular area within a reservoir that may be subject to waves from numerous directions. Cellular wave breaks and geotextile covers have been implemented by BC Hydro previously on reservoirs to protect heritage sites. The use of erosion protection structures such as a shoreline protection or wall or revetment (made from sheet pile, log-cribbing, riprap, gravel, cobble, loc-blocs, seeded geotextile bags, sandbags, poured concrete, or similar material) could also be constructed to help address the erosive force of waves. Vegetation can be used to protect against surface runoff in upland areas and to protect shallow, near-shore sites in the reservoir if suitable species can be identified.

8.2.5 Winter Ground Conditions

For potential effects from reservoir clearing, it may be possible to reduce adverse effects on heritage sites through use of winter harvesting on stable, frozen, and snow-covered surfaces, if no other effects such as inundation are expected (Hester 1992).

8.3 Systematic Data Recovery

In some instances, the nature of the proposed effect is such that a systematic data recovery program may be appropriate. Examples would include important heritage resources that would be destroyed during the development process. The scope of such a program is typically commensurate with the assessed importance of the resource and the magnitude of the effect. Some of the more common forms of systematic data recovery are described below.

8.3.1 Site Inventory

Additional palaeontological, archaeological, or historical survey work may be appropriate in some cases to address regulatory requirements, answer specific research questions, or to target landform types or potential classes more intensively. Methodologies for supplemental work would be similar to those employed in the current investigation and could potentially include areas of investigation outside the LAA.

8.3.2 Surface Collection

The collection of palaeontological remains and artifacts observed on the ground surface or in natural or man-made exposures can be an effective mitigation strategy. This approach typically involves systematic ground surface inspection, mapping and documentation of surface finds, and collection of all, or a sample, of the materials observed. For archaeological and historical artifacts, documenting the distribution and clustering of the materials is important for interpreting site activities and function. In general, this approach would be best suited to sites with no subsurface component, for eroded sites, or for shallow sites within cultivated fields.

8.3.3 Excavation

For important heritage resources that will be adversely affected by the Project, and where other more passive mitigation strategies (e.g., capping, relocation) are not viable for those locations, heritage site excavation is an option. Heritage site excavation can take a variety of forms, including fossil extraction and excavations at archaeological sites and some historical sites that include buried heritage objects and features. With respect to archaeological sites and to historical sites protected by the *Heritage Conservation Act*, the BC Archaeology Branch is ultimately responsible for determining the scope of such investigations. Any excavation work would occur under a *Heritage Conservation Act* S.14 Heritage Investigation Permit as issued by the BC Archaeology Branch. Due to the destructive nature of excavation, a data recovery program that retrieves as much data as possible using acceptable methods and techniques must be implemented, which helps to offset the loss of future opportunities for scientific research, preservation, or public appreciation. An appropriate research design for excavation should be problem oriented, adaptive, flexible, and where appropriate, include multi-disciplinary collaboration.

Under certain circumstances, it "may be in the best interest of the cultural resources" to excavate outside a zone of impact (Bergman and Doershuk 2003:89). An example of when this may be appropriate could be the investigation of a site or series of sites, designed to address specific research questions or community priorities.

8.3.4 Documentation

Documentation as a mitigation strategy may include detailed mapping of geological strata, recording of palaeoecological environments, or architectural recording of historical structures or features that cannot be protected in situ or relocated. The goal is to offset adverse effects and generate positive effects by creating a record of the strata, feature, or structure, supplement and update limited previous recording, and, in the case of previously recorded historical structures and features, provide a basis for evaluating the amount of deterioration that has occurred since the site was originally recorded.

While methodologies vary with the nature of the resource in question, common approaches include the following:

- Production of measured drawings at a precise scale from actual dimensions recorded in the field (e.g., plan and elevation drawings of historical structures); drawings may be produced either by hand or with computer-aided drafting (CAD)
- Detailed, high-resolution photographs and video
- Compilation of written histories and oral histories to place historical sites or structures within the appropriate context, addressing historical and architectural or engineering aspects
- Geological strata mapping using GPS

8.4 Monitoring

Construction monitoring, also known as surveillance, is often undertaken during excavations or other development-related activities as a means of mitigating project effects on heritage resources. Construction monitoring can be used as both a site discovery tool and as means of monitoring the systematic removal of known heritage resources so site information can be recorded and important objects collected. Construction monitoring typically involves heritage professionals and trained assistants who inspect development activities in heritage site areas.

A longer-term monitoring program, associated with project operation, may include erosion monitoring at known heritage site locations and the margin of the reservoir to document and recover important heritage materials that may become unearthed and to evaluate the performance of erosion protection measures that may have been undertaken at select sites.

8.5 Compensation in kind

With respect to archaeological resources and historical sites protected by the British Columbia *Heritage Conservation Act*, another approach to mitigating adverse effects is compensation in kind, which can be at a local, regional, or provincial level with the goal being to enhance public awareness and understanding of British Columbia archaeological or historical resources (BC Archaeology Branch 1998; Bergman and Doershuk 2003:89). The scope of such initiatives could be expanded to include palaeontological resources and historical sites not protected by the *Heritage Conservation Act*.

Compensation in kind can include, but is not limited to, replication (replacement) of a feature such as a historic trail segment, funding for museums (special exhibits, public displays, or volunteer programs), public education (such as school programs, school teaching kits, publications, improved signage or adding new signage at unmarked sites, community lectures, web sites, documentary film, or video), or creating an interpretive site such as the Xat'súll Heritage Village at Soda Creek, British Columbia. A public-oriented archaeological program that includes a field school under the direction of a local college or university and provides opportunity for public involvement (through volunteer positions or hiring of interested local community members) is another example of how compensation in kind can be used as a form of mitigation.

9.0 STUDY LIMITATIONS

This study aims to provide an explicit, replicable basis for making palaeontological, archaeological, and historical resource management decisions within the LAA, and for guiding future heritage resource studies. However, the accuracy of the results and recommendations of this study are limited by certain factors that are discussed below.

Information on palaeontological resources in the LAA presented in this report is based on field studies and a detailed search of relevant literature, databases, and maps held by various repositories. Although considered generally reliable, errors of fact or interpretation may exist in the palaeontological literature. Furthermore, while attempts have been made to identify the most relevant sources, additional information about palaeontological resources in the Project area may exist and could alter some specific technical interpretations of this report.

Information on archaeological resources presented in this report is based on documentary review (including retrieval of unpublished field data and data-sets from previous Site C archaeological studies conducted by SFU), the Millennia Research archaeological predictive model, and newly acquired data from the 2010 – 2012 field seasons.

Efforts were made to verify the accuracy of older archaeological data. However, archaeological methods and standards (e.g., testing, mapping, reporting, etc.) have changed over time and the quality of the archival data varies considerably.

Archaeological field data from the current program are based on surface inspections and subsurface testing (i.e., manually using shovels and mechanically using augers and backhoes). While efforts were made to record and plot data points accurately, the quality of spatial data provided may vary due to normal fluctuations in the precision of GPS readings.

Information regarding historical resources in the LAA presented in this report is based on research undertaken at a number of repositories in B.C., field surveys, and information provided by stakeholders guided by a questionnaire. While the intent has been to identify and review all pertinent sources held by these repositories, historical research can never claim to be exhaustive, being inherently limited by, for example, record making and record-keeping decisions, errors in filing, the quality of finding aids, and access restrictions. Moreover, the absence of specific information cannot be interpreted to either confirm or deny assumptions relating to the subject of this research. The potential therefore remains for further information related to historical heritage in the LAA to be revealed and potentially change specific interpretations or conclusions that may have been derived from the documentation discussed in this report. The overall conclusions and the assessment of the significance of residual effects are not expected to change based on additional information, assuming appropriate mitigation measures are employed to address any new information.

Field studies for each discipline were limited to those areas within the LAA, for which property access had been secured and for which development plans are sufficiently advanced. Access restrictions may influence the identification of site location patterns and other attributes within the LAA.

The assessment of potential Project effects is based upon Project information provided by BC Hydro, and is assumed to be reliable.

Given these qualifiers relating to palaeontological, archaeological, and historical research and the information gathered through that process, the assessment has relied upon the information provided and collected and the authors accept no responsibility for any deficiency or inaccuracy contained in this report as a result of that reliance.

Field inventory and assessment of heritage resources are still required for:

- Construction of access roads
- Off-site quarry and excavation construction materials areas
- A transmission line tie-in at Peace Canyon Dam Generating Station
- One on-site construction material source that is under consideration
- Existing infrastructure that may require relocation, such as buried services and pipelines
- A possible [redacted] (HbRh-2), if the location cannot be avoided by the Project

In addition, private land parcels for which access is currently restricted have yet to be inventoried. Undefined construction activity areas near the dam site, should they be required, will also be inventoried.

Field work would be completed in a manner consistent with the current heritage assessment prior to the start of construction in these areas, with the following addition:

- Field work proposed for the Del Rio Pit and Wuthrich Quarry would include mapping of observed subsurface test locations conducted during previous archaeological assessments by other consultants. The test locations would be added to the Project's database of subsurface test locations.

Reports on future heritage assessment work would be submitted to relevant Provincial agencies and Aboriginal groups in accordance with legislative and permit requirements.

10.0 USE OF REPORT BY THIRD PARTIES

The findings and conclusions documented in this report have been developed in a manner consistent with that level of care customarily exercised by heritage professionals currently practicing under similar conditions in northeastern B.C. The authors make no other warranty, expressed or implied.

This report was prepared for the use of BC Hydro the BC Archaeology Branch, and the Joint Review Panel. BC Hydro has the right to reproduce, use, and rely upon this Report for proper purposes in planning, operating, and maintaining the electrical generation, transmission, and distribution system in the Province of British Columbia, including, without limitation, the right to deliver this Report to regulatory authorities in support of or in response to regulatory inquiries and proceedings, including environmental assessment. Any other use, reliance, or decisions made by third parties on the basis of this report are the sole responsibility of such third parties.

11.0 CLOSURE

We trust the information contained in this report is sufficient for your present needs. Should you have any questions regarding the Site C Clean Energy heritage impact assessment program, please do not hesitate to contact Andrew Mason at amason@golder.com.

GOLDER ASSOCIATES LTD.

Jeff Bailey, M.A., RPCA
Associate, Senior Archaeologist

for Andrew Mason, M.A., RPCA
Principal, Senior Archaeologist

AMEC ENVIRONMENT & INFRASTRUCTURE

Arnoud Stryd, Ph.D., RPCA
Senior Archaeologist and Project Manager

Diana Alexander, M.A., RPCA
Archaeology Group Lead

JB/ARM/AS/DA/asd

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12.3 Personal Communications

BC Hydro. 2012. Community Relations Manager, David Conway. Email conversation September 29, 2011.

Patrick, C. 2012. Deputy Director – Technical Manager, Beta Analytic. Email conversation September 17, 2012.

APPENDIX A

Glossary

Many terms and abbreviations used throughout this report have anthropological, archaeological, and paleontological importance and may be unfamiliar to non-specialists. These terms are defined below. In addition, this list also defines frequently used abbreviations.

Term / Abbreviation	Definition
Albian	Uppermost stage of the Lower Cretaceous, spanning 107 and 95 million years BP.
Alluvial Sediments	Sediments deposited by streams and rivers. The texture of these deposits is contingent upon the energy of the watercourse responsible for their deposition; thus, silt and fine sands are deposited in low-energy aquatic environments, while coarser gravels and cobbles are deposited by high-energy streams.
Ammonite	An extinct group of marine invertebrates that were the ancestors of modern squid and octopus. The fossils of these marine molluscs are very useful for dating sedimentary rock.
Angiosperms	Seed producing plants distinguished by their ability to flower and produce fruit.
Anthropogenic	Anything derived from human agency, as opposed to anything occurring in natural environments without human influence.
Archaeological Site	An archaeological site is a location that contains physical evidence of past human activity, and which can be studied by archaeological methods of investigation, including site survey, excavation, and data analysis (Archaeology Branch 1998).
Archaeology	The study of the human past, including the historic past, through the empirical study of material remains (that is, physical evidence of past land use and settlement).
Artifact	A portable object made, modified, used, or transported by humans; includes both finished objects (tools, ornaments) and the waste products of tool manufacture (detritus, debitage, flakes).
Artifact Scatter	Two or more artifacts clustered together. Usually indicative of an association with ancient activity areas (e.g., lithic manufacture, campsite, village location).
Auger	A device for extracting samples of deeply buried sediments (1.5 - 2.0m) used to aid in the identification of sub-surface archaeological materials.
Bedrock	The native consolidated rock that underlies the surface of the earth. The exposure of bedrock is referred as an outcrop. In the Site C area the term generally refers to pre-Quaternary or Cretaceous sediments which may or may not be solidified.
Biostratigraphy	the use of fossils in the application of palaeontological principles to establish stratigraphic frameworks in time and space
Bivalves	Any type of fossil comprising two shells such as clams or oysters.
Borden Number	A standardized convention consisting of four letters and one number (e.g., HaRk-1) uniquely assigned to a specific archaeological site, which identifies it and denotes its general location in Canada.
Before Present	Dating convention in which BP refers to years Before Present, with present established as AD 1950.
Calcined	Denotes bone that has been burnt to the extent that is reduced to its white/blue mineral constituents.
Carbonaceous	A sedimentary rock with a high proportion of organic material.
Cenomanian Age	Lowermost stage of the Upper Cretaceous, spanning 95 and 91 million years BP.
Chalcedony	A translucent to semi-opaque, cryptocrystalline silicate mineral, typically of sedimentary origin.

Term / Abbreviation	Definition
Chert	A fine-grained, opaque rock composed of microcrystalline silicate minerals.
Chi tho	An Athapaskan word denoting a large, discoidal to semi-lunate tool used for hide-preparation. Usually manufactured from very hard, coarse-grained stone like quartzite. Commonly referred to as a spall tool.
Colluvium	Sediments deposited at the base of a slope by gravity.
Contact	The first prolonged, direct encounters between Aboriginal peoples and Europeans. In the Project area the contact period spans from the arrival of Alexander Mackenzie in 1793 to the establishment of trading posts between Fort St. John and Hudson's Hope in the mid 1800's. Hence, in this region the Pre-Contact period is the time before 1793, while the Post-Contact period begins with the arrival of settlers of European descent in the mid-1800s. The Post-Contact period is characterized by contemporary written records and a material cultural dominated by items of industrial manufacture. The Post-Contact period is often referred to as the Historic Period.
Coprolite	Fossilized animal excrement.
Core	A piece of stone from which flakes have been removed as part of the tool manufacture process. Cores are sometimes specially prepared so that flakes of predictable size and thickness can be produced.
Cretaceous Age	The final period of the Mesozoic Era spanning 145 and 65 million years BP. It is subdivided as Lower Cretaceous, 145 to 100 million years BP, and Upper Cretaceous, 100 million to 65 million years BP.
Cultural Deposit	Accumulated sediments directly produced or modified as the result of human activity. Typically comprised of stratified layers of anthropogenic soils, charcoal, ash, fire-altered rocks, faunal remains, and artifacts. Human remains may be present in such deposits.
Cultural Depression	A pit or hollow excavated into the land by human agency. In this region, cultural depressions are more typically associated with food storage (see: cache pit); habitation features (e.g., pithouses) are either very rare or absent, aside from historic sites.
Culturally Modified Tree	A tree that has been intentionally altered by First Nations' people through their traditional use of forest resources (for food, manufacture, or medicinal purposes). Cambium-stripped lodgepole pine trees are the most common CMT type in northeastern B.C.. A cambium-stripped CMT is a tree from which a section of bark has been removed to access the underlying cambium layer for food, resulting in a typically lenticular scar on the tree trunk.
Culture	The distinctive lifeway—including language, technology, sustenance, social organization, customs, beliefs, and rituals—practised by a society. The term can also be used to refer to the culture of particular groups of people at a particular point in time. In an archaeological/ethnographic context, the term cultural refers to materials or objects of human origin, and can be considered to be the opposite of natural.
Debitage	The unused by-products of stone tool production and rejuvenation, and including flakes, flake shatter and block shatter. Also referred to as detritus.

Term / Abbreviation	Definition
Digital Elevation Model	A digital representation of ground surface topography or terrain. It is also widely known as a digital terrain model (DTM).
Draw-down	The temporary diminishment of the water level in a dam reservoir. During the normal course of operations for a reservoir, or during maintenance to a dam, the Water Level in the reservoir is subject to seasonal and/or temporary reduction. During this period, there is a greater outflow of water from the reservoir outlet than the inflow of water from the rivers that flow into it. Submerged lands around the margin of the reservoir become exposed.
Ericaceous	Ericaceous: Referring to Ericaceae, more commonly known as the heath or heather family.
Faunal Remains	The remains of animals discovered in an archaeological context. Archaeological fauna generally denote food remains, although some may have had ceremonial significance.
Feature	Non-portable archaeological remains including hearths, storage pits, and cooking ovens. May also consist of individually portable items like boulders that form the outline of a moose-hide shelter.
Flake	A thin, flat to slightly-curved fragment of stone removed from a core during stone tool manufacture. Flakes exhibit distinctive physical attributes by which they can be differentiated from naturally-fragmented rocks.
Fluvial Sediments	See Alluvial Sediments.
Formation (geological)	The name given to a succession of strata with specific characteristics that can be recognized as distinct from other successions of strata in the region where it occurs.
Fossil	The remnant or trace of an ancient living organism that has been preserved in sedimentary rock or in some instances, reworked into gravels.
Fossil Assemblage	A group of fossil species found in a specific sequence of sedimentary rock.
Fossil site	A geographical location where significant fossil material is discovered. Sites are often given a formal designation by federal or provincial governments.
Fossiliferous	Rocks which have many fossils.
Gastropod	Shelly animal fossil, generally coiled, such as a snail, periwinkle or conch.
Geological Map	A map which shows the distribution of rocks exposed on the earth's surface including areas, if covered by overburden (e.g., soil and vegetation),with the overburden stripped away
Geographic Information System	A computer program used to map land and organize thematic information.
Glaciolacustrine	Sediments deposited at the bottom of short-lived, periglacial lakes; in the Project area, will be associated with Glacial Lake Peace.
Global Positioning System	A navigation system that allows users to determine their location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world.
Hearth	An archaeological feature that was used as a fire place, minimally consisting of fire-altered rocks and charcoal.
Hillshade	A digital representation of a digital elevation model that mimics the sun's illumination to give a life-like graphical rendition of the topography.

Term / Abbreviation	Definition
Holocene	The most recent epoch of geological history spanning 12,000 years BP to the present. Together with the Pleistocene, forms the Quaternary period.
Humic	See Littermat.
Ice Age	A period in the Earth's ancient history when ice sheets covered vast regions. In this report, the term refers to the Pleistocene glacial epoch, from 2.5 million to 12,000 years BP. In the study region, the Ice Age ended approximately 11,500 years ago, when the glaciers retreated significantly.
Ichnite	Fossilized footprint.
In Situ	An object in its original position, that is, not disturbed.
Inoceramus	A large fossil bivalve, important as a geological time-marker.
Invertebrate Fossil	Fossil of an animal that did not possess a backbone. In the fossil record, most invertebrates are of marine origin.
Isolated Find	An artifact found in isolation, where no other artifacts have been identified within 50 metres.
Judgemental Sampling	Choosing archaeological test locations on the basis of pre-determined potential assessments or in-field observations suggestive of high archaeological potential.
Lacustrine	Refers to lakes. In this report, used in the context of sediments deposited in lakes. Sediments deposited in lakes known to be glacial meltwater features are called glaciolacustrine.
Light Detection and Ranging	A remote-sensing tool used for fine-grained terrain mapping.
Lithic	Pertaining to stone. A lithic artifact is one manufactured from stone.
Lithic Scatter	Two or more stone artifacts clustered together. Generally indicative of tool manufacture or repair.
Littermat	In a soil profile, the uppermost layer of partially decomposed organic material overlying other soils horizons.
Mesic	Adequate soil moisture retention year round.
Microfossils	Remains of very small organisms that require magnification for study. The category encompasses a heterogeneous array of minute fossils including fauna, flora, unicellular, multicellular, mineralized, and organic. Very useful for paleoenvironmental reconstruction.
Microtopography	Relatively minute changes (conventionally less than 15m) in the surface of the earth.
North American Datum	Geo-spatial reference standards developed for mapping purposes in Canada and the United States. Thus, "NAD27" refers to the North American Datum of 1927 used by Canadian NTS maps. "NAD83" refers to North American Datum of 1983, presently used by modern digitized mapping systems and GIS programs.
National Topographic System	National Topographic System; Canadian Federal government mapping system.
Oil & Gas Commission (of British Columbia)	A government agency responsible for permitting and oversight of petrochemical exploration and development in this province.
Palaeoflora	An assemblage of fossil plants.

Term / Abbreviation	Definition
Palaeontological Resource	Proven or suspected fossil occurrences which could be important scientifically or culturally.
Palaeobotanical	A term relating to ancient plants or ancient plant life.
Palaeontology	The study of ancient life as represented by fossils preserved in rocks.
Point of Intersection	In this study, used for geo-spatial referencing of topographic features with previous archaeological records.
Pleistocene	The epoch of geological history spanning from approximately 2.5 million years BP to 12 000 years BP. Comprises the most recent period of repeated glaciations. Together with the Holocene, forms the Quartenary Period.
Post-Contact	See Contact.
Pre-Contact	See Contact.
Prehistoric Period	See Contact.
Projectile Point	A sharply-pointed artifact once mounted on a wooden shaft and used for piercing game animals after being thrown or propelled. Includes spear and atlatl dart points as well as arrowheads. Projectile points may just as often have been used as knives by their makers.
Provincial Heritage Register	A centralized listing of protected heritage sites and objects, buildings, structures and other non-archaeological sites.
Quadrat	A 500m^2 block of terrain selected as a study area for archaeological surveys conducted by Simon University in the Site C Project area during 1977, 1978, and 1981.
Quadrito	A miniature version of the quadrat used in the Simon Fraser University's archaeological survey of the Project area in 1977-1978.
Quarry	In archaeological context, it refers to a location where stone materials were acquired for tool manufacture.
Quaternary	The period of geological history spanning from approximately 2.5 million years BP to present. Comprising of Pleistocene and Holocene epochs.
Random Sampling	Using a computer or other non-biased method to choose pre-determined locations for archaeological testing
Retouched Flake	A flake exhibiting a minimal amount of deliberate modification along one or more margins (edges) to quickly produce an expedient tool.
Riparian	Denotes the moist to mesic habitat present along the margins of streams and lakes.
Sandstone	A sedimentary rock composed predominately of sand sized particles. Primarily comprised of cemented quartz grains with lesser amounts of feldspar.
Scraper	A stone artifact typified by an obtusely angled, convex margin, used for preparing animal hides or stripping bark from twigs and branches. Types of scrapers with straight and concave margins are known, but are not as common in the Project area.
Sediment Exposure	Areas where the underlying sediments do not have coverings of soil or vegetation.
Sedimentary Rock	Rock formed by the accumulation and consolidation of loose particles and minerals called sediment. Also see Sediments.

Term / Abbreviation	Definition
Sediment	Loose particles and minerals from the Earth's surface deposited on the landscape through agents of denudation (e.g., water, wind, glaciers). Sediment is produced by various means including: mechanical (e.g., weathering or erosion of older rocks), chemical (e.g., precipitation from a solution), and organic (e.g., limestone constructed from the remains or secretions of organisms)
Shale	A sedimentary rock composed of indurated clay and particles of other minerals such as quartz and calcite.
Shatter	Cubical to polyhedral, angular pieces of worked stone lacking the distinctive attributes of a flake, produced as byproducts of stone tool manufacture.
Shovel Test	A standard method for archaeological sub-surface survey. Test pits are dug to determine whether the substrate contains cultural remains not otherwise visible on the surface. Excavated sediments are normally screened through or 6 mm (¼") wire mesh to recover the artifacts and other small cultural materials.
Siltstone	A fine grained sedimentary rock primarily composed of silt sized particles. It is finer than sandstone, but coarser than shale.
Site Inventory	A site inventory is intended to find and record heritage resources (*e.g.*, sites) within a specified development area or landscape. Sites are normally identified by pedestrian traverses across a landscape, supplemented by subsurface testing to find buried cultural remains.
Subsurface Testing	A method used by archaeologists to locate and identify subsurface archaeological remains (e.g., shovel testing, auger testing).
Stratigraphy	In the context of this report, it refers to the vertical subsurface layering of soil and rock layers or horizons.
Sub-hygric	Moderately well to imperfectly drained soils.
Surficial Geology	The geological study of the surface, or near surface of the earth.
Survey Transect	Strips of terrain selected for intensive, pedestrian inspection by archaeologists. Subsurface tests are conducted at pre-determined points along the transect.
Systematic Testing	Subsurface testing for buried archaeological materials at pre-determined, regular intervals, with the distance between the tests contingent on the research goals and the kinds of archaeological materials expected.
Terrace	A relatively level to gently-inclined landform, typically created by the deposition and erosion of alluvial or lacustrine sediments.
Terrain Resource Information Mapping	A system that provides digital map data for the province of British Columbia. Specifications include documents on base-mapping, scanning aerial photos, gridded DEM and the SAIF standard.
Tagged Image File	Denotes a digitized graphic image.
Tool	An artifact that has been modified or formed for a specific purpose (e.g., projectile point, knife, scraper).
Unconsolidated Sediment	Sediment that has not been compacted or indurated.

Term / Abbreviation	Definition
Vertebrate Fossil	Fossil of an animal possessing a backbone. Important ancient fossils examples are dinosaurs and mammoths.
Wedge	A piece of material, such as antler or wood, thick at one edge and tapered to a thin edge at the other for insertion in a narrow crevice, used for splitting, tightening, securing, or levering.
Wetland	Land inundated by surface water or ground water percolation, sufficient to support the growth and reproduction of riparian vegetative and aquatic life. Distinct classes of wetland in or near the Project include bogs and marshes.

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APPENDIX B

CartoPac User Guide

December 7, 2012
Report No. 12-1423-0008

1.0 INTRODUCTION

The CartoPac application consists of study area maps and forms for data collection. Field crews navigate using the GPS and maps to an area that needs to be assessed, and then record observations and test results in forms that are geo-referenced to the location.

The CartoPac application is intended to largely replace the field notebook. It is designed with forms that allow for the recording of archaeological potential assessment, shovel tests, surface and subsurface features (including CMTs), surface artifacts, artifact collections, and sample collections. These observations can be made about a particular point (e.g., a shovel test), a line (e.g., a trail), or a polygon (e.g., an area of high archaeological potential).

For Phase 1 of the study, pre-set observation points representing shovel tests for each transect will have been put on the Trimble data logger using the CartoPac software. Crews will navigate to these points, excavate shovel tests, and record the results in the data logger. In addition to these predetermined shovel test locations, other observations can be made such as surface lithics or features seen during the traverse.

2.0 GETTING STARTED

A “project ” is a section of the reservoir that a crew is assigned to assess, such as a transect or tract. The project will be prepared by the GIS department for uploading to the Trimble in a file called a CartoPac Remote Project Container, with the file extension “.crpc”. The job consists of transects and test points. The underlying imagery is already loaded on the Trimble unit on the SD card. CartoPac has an option to automatically select the correct map for the job, or it can be selected manually, as described in the “Imagery” section below.

The jobs will typically be loaded and unloaded for you by an office admin person overnight. Please check to make sure your job(s) are loaded and you have an active mobile licence before leaving the office. For details on how to load/unload jobs, please see the SLIDE overview in section below. You will need three pieces of software in order to move projects on and off the Trimble:

1. Slide software(http://slide.cartopac.com/3.1/sliderpc),
2. the mobile software, including a license manager, loaded onto your computer (http://download.cartopac.com/products/cartopac/CartoPac.msi)
3. ActiveSync (Windows XP) or Microsoft Mobile Device Manager (Vista or Windows7) http://www.microsoft.com/windowsmobile/en-us/help/synchronize/device-synch.mspx

CARTOPAC Workflow Overview

1. The coordinator determines the transect lines the field worker will be crossing for that day/week.
2. The GIS department downloads to Remote Project Container (this is essentially a zipped up project) and e-mails this container to the admin/field worker.
3. The admin/field worker receives the RPC by e-mail, opens SLIDE and downloads the RPC to device.
4. The field worker collects data in the field.
5. At the end of the day (and/or completion of the transect line), the admin/field user uploads the project to remote project container using SLIDE.
6. The admin/field user e-mails the RPC to the data manager (bcampbell@golder.com).
7. The data manager receives the RPC by e-mail, checks that the file is complete, then forwards to GIS.
8. GIS opens the ArcMap.mxd and uploads the RPC to the project.

Opening and closing a Job

The unit can store multiple “jobs” on it, but only one can be open at a time to add data to.

To start the CartoPac software on the Trimble, tap the “Start” menu (upper left), and then tap “CartoPac Enterprise”. Then go to the “File” tab (lower left), and select “open” in the menu. Select the project you want to work on and tap “open”.

To close a job, close the CartoPac application by going to the “file” tab (lower left) and select “exit” from the menu. A job can also be closed by opening another job, as described above.

3.0 RECORDING DATA

Note: The screens shots below are not exactly as seen on the Trimble unit. On the Trimble unit the “ok” button is displayed in the upper right hand corner.

After opening the job, a black line or series of lines will show up on the screen (Figure 1) which, when zoomed into, will display individual test locations (Figure 2). Click on a test location dot with the **select tool** turned to the **“i” mode**, and a form will open up as shown in Figure 3.

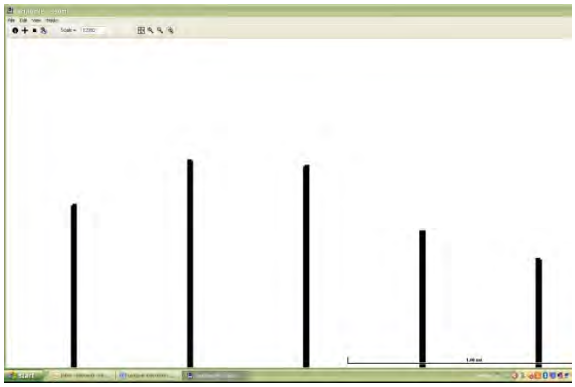


Figure 1

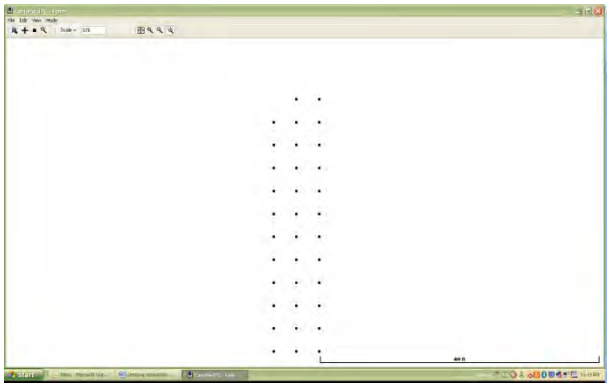


Figure 2

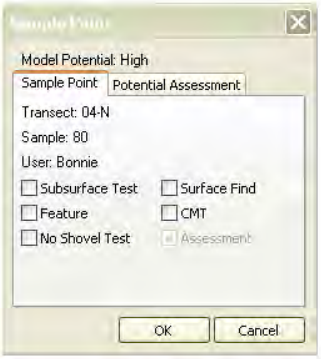


Figure 3. This is the the ‘main menu’, where you will select what types of observations are being made for this point. There are six forms available:

Subsurface Test
Surface find,
Feature,
CMT,
‘No Shovel Test’ and
Potential Assessment.

When you click a box, the tab for the form will pop up, such as for the Potential Assessment form. Subforms will pop up when

Note: The “Potential Assessment” tab will be automatically selected as a required field during Phase 1.

3.1 POTENTIAL ASSESSMENT

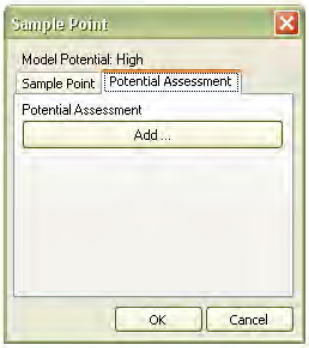


Figure 4. To open the form under a tab, click add.

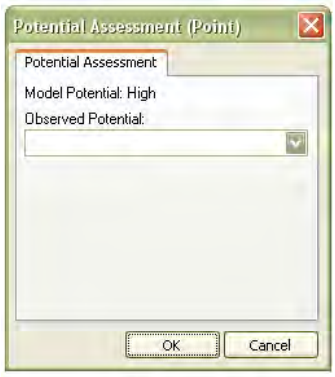


Figure 5. For points that are predetermined, the form will pre-fill the Model Potential. Since this predeteremined location is in a high potential polygon, the model potential shows High. Fill in your observation about model potential. If it agrees, you are done and can hit “ok”.

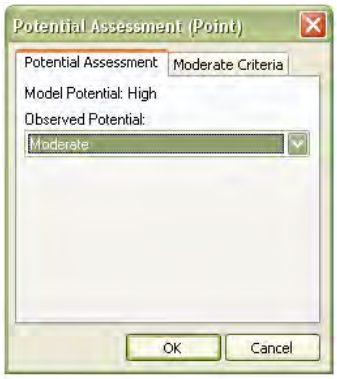


Figure 6. If your assessment disagrees with the model, you will be asked to indicate what features are present at the location to support your assessment. The features show up on a pop-up tab to fill out and provide comment.

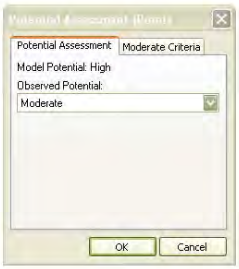


Figure 7. If you don’t fill it out, you will get a message redirecting you back to the tab.

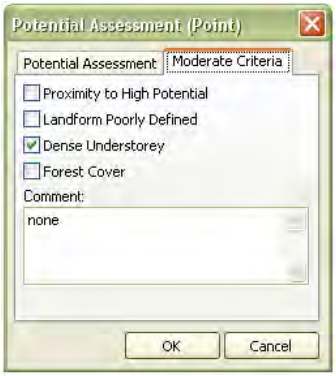


Figure 8. We have provided some of the basic criteria, and there is a comment section to fill out if more detail is needed. The comment field is a required field, so you will have to enter something to complete the form.

Figure 9. The ‘Low” criteria filled out.

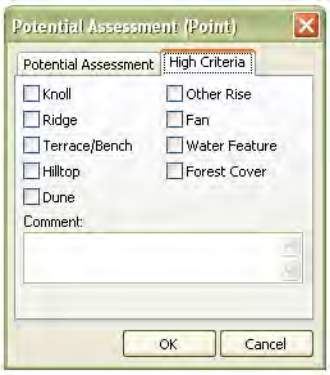


Figure 10. High Criteria.

When you are done, tap “OK” to return to the main form menu.

3.2 NO SHOVEL TEST - PHASE 1 ONLY

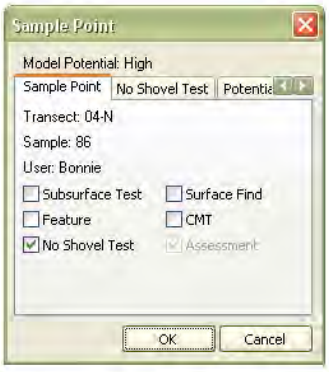


Figure 11. During Phase 1, tests in the high and moderate are excavated on a 10 m grid interval; low potential will have a larger grid interval. There may be cases where a test cannot be excavated for any number of reasons. It is allowable to move a shovel test up to 4 m in any direction from the centre of the 10 m cell in order to find a place to dig. If there is no place to test, the test should be recorded using this form.

Figure 12. To open the form under a tab, click add.

Figure 13. Select one or more reasons as to why the test cannot be excavated, and provide any comment necessary. No test options are: water saturated, boulder, pavement, compacted, bedrock exposure, trees, roadbed, slope, other. If the field condition is not on the list, please be sure to include a comment so that the list can be updated.

When you are done, tap “OK” to return to the main form menu.

3.3 SUBSURFACE TEST

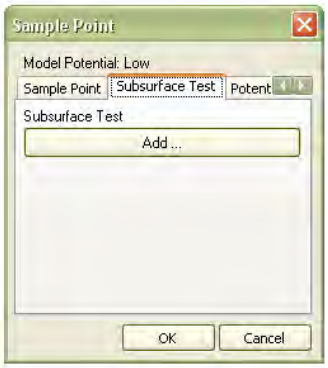


Figure 14. To open the form under a tab, click add

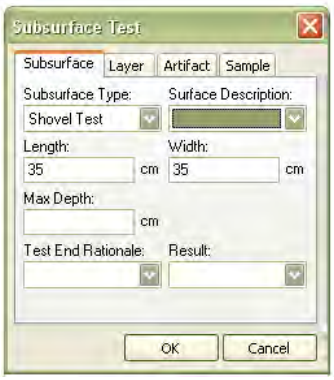
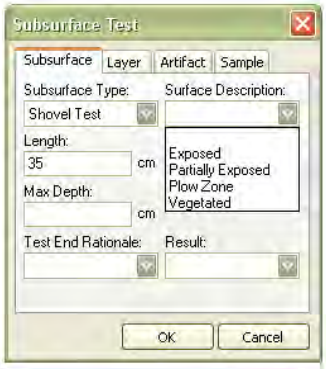
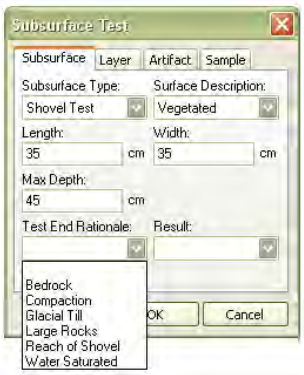


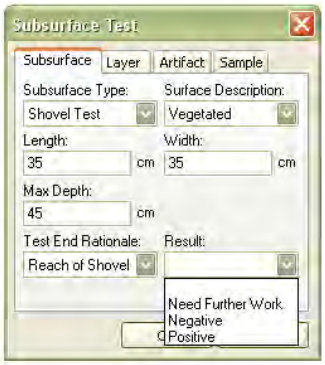
Figure 15. The subsurface test form has five sub-forms:

1. subsurface
2. comment
3. layer (2 pages)
4. artifact
5. sample

3.3.1 SUBSURFACE TAB – MAIN PAGE







Complete the main subsurface test form page by inputting values or selecting options from drop down menus. The form will default to shovel test and 35 x 35 cm for length and width. The menu options for the fields are:

Subsurface Type: Shovel Test, Auger Test, Backhoe, EU (evaluative/ excavation unit)

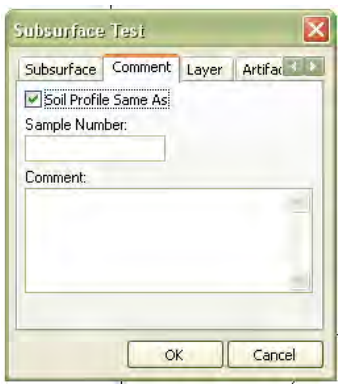
Surface Description: Exposed, Partially Exposed, Plow Zone, Vegetated.

Length, Width, Max Depth: enter numeric values in centimetres.

Test End Rationale (i.e., why the test ended): Bedrock, Compaction, Glacial Till, Large Rocks, Reach of Shovel, Water saturated.

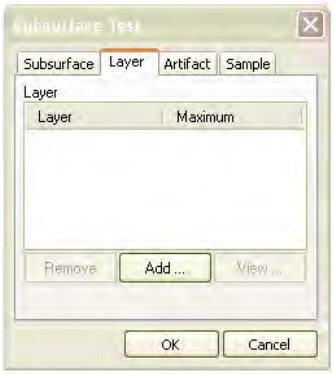
Result: Need Further Work, Negative, Positive, Palaeontology only. “Need Further Work” should be used where either the test location needs to be revisited or there is some aspect of the result that needs further analysis. Examples would be the need to bring in an auger or backhoe to dig deeper, or to have potential artifacts examined in the lab to determine if the test is positive or negative.

3.3.2 COMMENT TAB



The comment tab provides a place to make any extra observations about the shovel test or locality of the test. There is also a place to indicate that the soil profile is the same as another test, to avoid having repeat data entry. The identification number of the reference test must be entered under “sample number”.

3.3.3 LAYER TAB



The layers of stratigraphy are recorded by filling out a “layer” form for each layer. To open a layer form tap the “Layer” tab, and tap “Add”. A “layer” form is added for each stratigraphic layer. Once one layer is described, hit “ok” to return to this menu add the next layer to be described.

This figure shows a sample layer description for the first layer, 0-25. There are two pages to this form; Layer Desc 1 and Layer Desc 2. Please fill out both as much as needed.

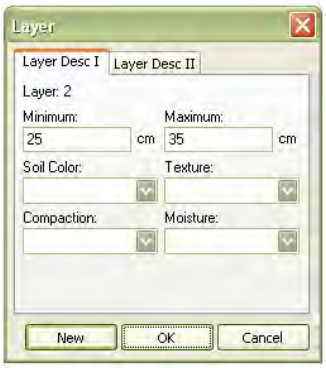
The first page defines the layer parameters (max and min depths), describes soil color, texture, compaction and moisture.

The second page describes the major large particle inclusions if present (e.g., gravel) and what percent present, as well as their shape. The idea is to record the major inclusions. However, if additional particle classes need to be recorded, please use the comments field.

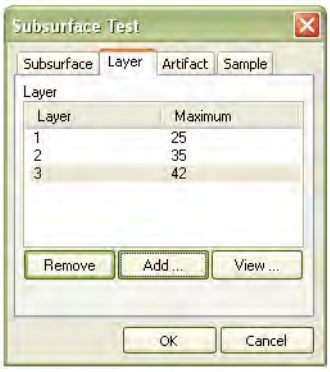
Condition and Disturbance Factor should be used to describe any distrubance in the layer. Note that if “intact” is selected, the ‘distubance factor’ fades out and cannot be filled in.

To add the next layer, tap OK on the previous screen, taking you back to the main page of the Layer form.

Tap “add” and the layer 2 form shows.

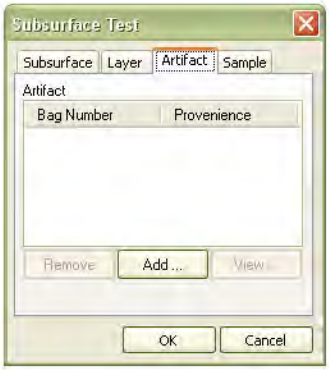


Fill out form (page 1 and 2), hit “ok” and repeat process until all of layers are recorded.



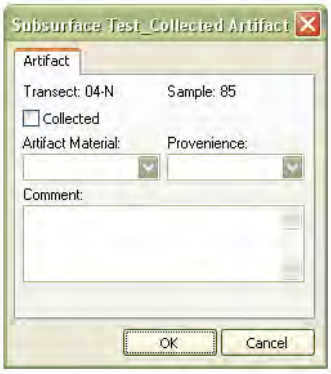
The main page of the layer form keeps track of the layer forms so the operator can see what has been done so far.

3.3.4 ARTIFACTS

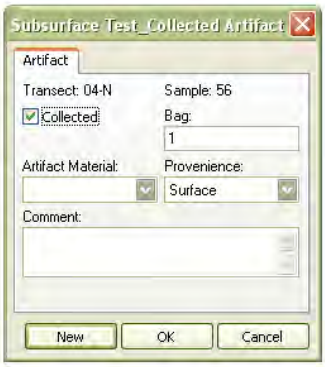


ARTIFACTS – this form is used to document artifacts, whether collected or observed in situ.

Tap “add” to open a form.



If artifacts are being observed but not collected, leave the ‘collected’ unchecked and complete the Artifact Material and Provenience information from the drop down menu. The recorder is not required to do a detailed count or any analysis in the field.



If the artifacts are collected, check the “collected” box and note that “Bag: ” appears for the operator to fill in. Artifacts should be collected in lots, with one bag per lot. The bag should be identified in the field with the date, tract/transect number, operator initials, and the **bag number**.

If there is more than one lot, tap “ok” to return to the Artifact tab and tap ‘add’ for the next bag number and description.

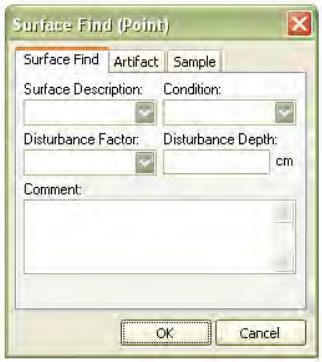
Provenience: The provenience tab has options of Surface, No Provenience, or a number value representing a stratigraphic layer. “No provenience” is used where the artifact has fallen in off of a wall without provenience, or it is recovered from a shovel test that was not excavated in controlled layers. If artifact provenience is known, indicate which layer it originated from. The layer numbers should correspond with the layers described under the Layer tab.

Use the comment field to add any additional information, such as detailed provenience or other notes that lab personnel should be made aware of.

3.3.5 SAMPLES COLLECTED

SAMPLES
Like the artifact form, a sample form should be filled out for each sample collected from a subsurface test. Unlike the artifact bag, the software will autogenerate a bag number for your sample.

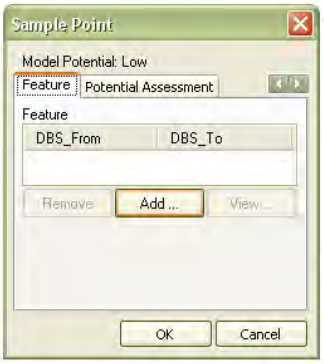
3.4 SURFACE FIND



The surface find form has three parts: surface find, artifact and sample. The main surface find form has five fields to complete using drop down menus or numeric inputs. Use the comment field to add any other information.

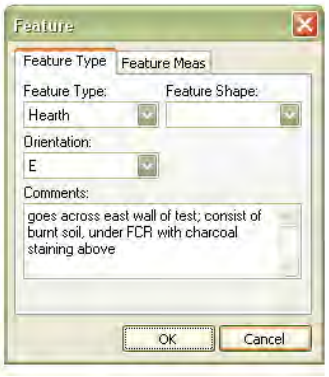
The artifact and sample forms are the same as those used for the subsurface test.

3.5 FEATURE



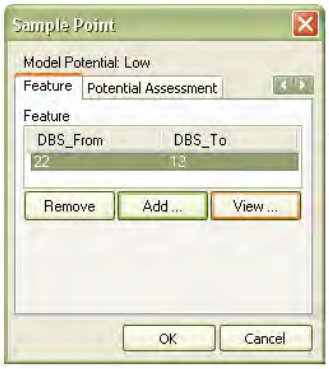
The feature form can be used for surface or subsurface features, and can be used for all types of features except for CMTs, which has a separate form. If a feature is encountered during testing, return to the main menu and click the feature box to have the feature form tab appear. It is also possible to record more than one feature at a point, such as multiple hearth features in a shovel test. A feature form should be filled out for each feature.

To open a form , tap “add”.



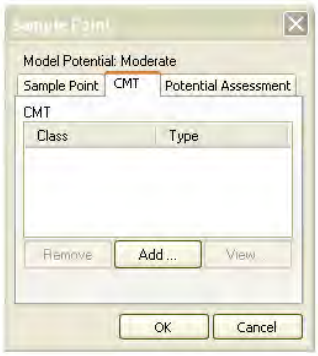
The Feature Form is two pages long. The first page is the feature type, wiht drop down menus. Orientation will depend on the type of feature being recorded and is up to individual recorders to apply.

The second page is feature measurements. Again, which fields to fill out will depend on whether the feature is surface or subsurface.

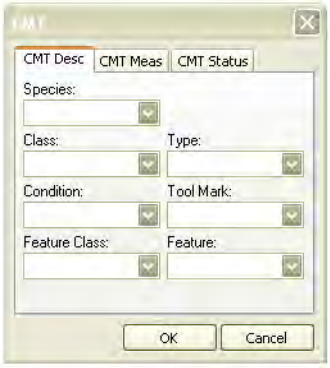


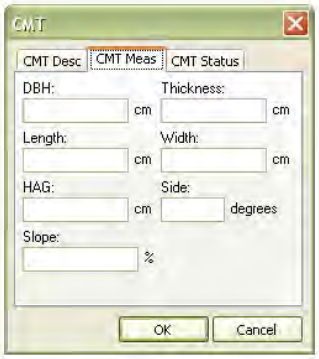
When the form is completed, tap “ok” to return to the main feature screen. The list of feature forms that have been completed for this location can be reviewed or more features added under this data point

3.6 CMT



CMT
The CMT form is three pages long and is based on the CMT Handbook. Multiple features can be recorded for one CMT by adding forms.





Please refer to the CMT handbook for measurement and recording instructions

For CMT status, please provide an in-field assessment of the age of thee modification if possible, and indicate the basis for the assessment. Use the comments field for rationale as to why no age assessment can be made, or any other pertinent information.

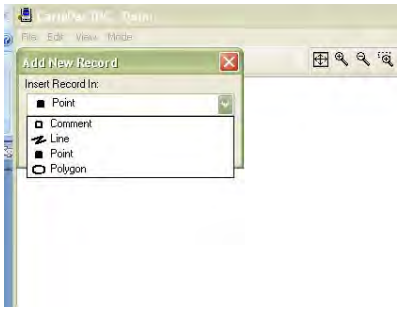
4.0 Adding New Point, Line or Polygon Records

During Phase 1 crews will be working almost exclusively with predetermined point data (i.e., the number and location of tests is determined ahead of time.). During Phase 2, additional shovel tests or other types of tests will be excavated, or areas of surface scatters or historic features will be delineated.

The operator can add a new shovel test (point), line (e.g., trail), polygon (e.g. area of high potential not on model; area of disturbance)

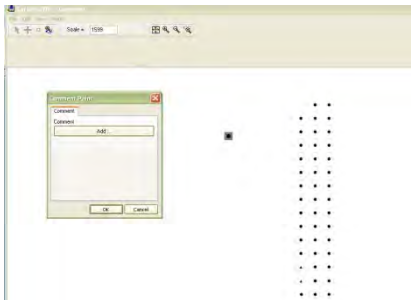
The operator can add the following types of records by clicking on the "+" button at the base of the screen:

1. comment	This is a point record. Brings up an all-purpose blank "comment" page.
2. line	After line is created, all forms available except for 'subsurface test' and 'comment'.
3. point	After point is created, all forms available.
4. polygon	After polygon is created, all forms available except for 'subsurface test' and 'comment'



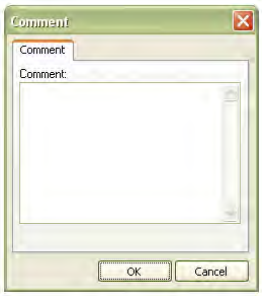
Tap the "+" symbol to activate the "add a new record" menu

To add a comment, select comment then tap create. The screen will go blank (i.e., the interactive menu disappears) until theoperator touches the screen to indicate where the comment is to go.

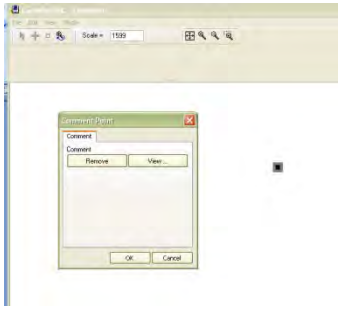


Touch the screen and the comment form will pop up, as well as a new waypoint showing where the comment is georeferenced to.

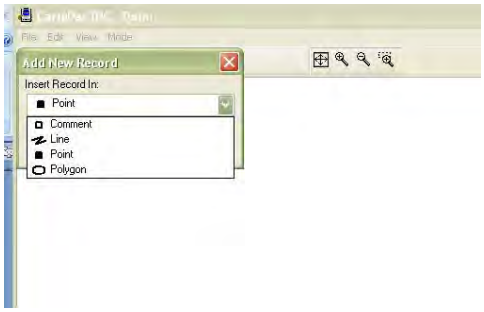
Tap "add" to open the form.



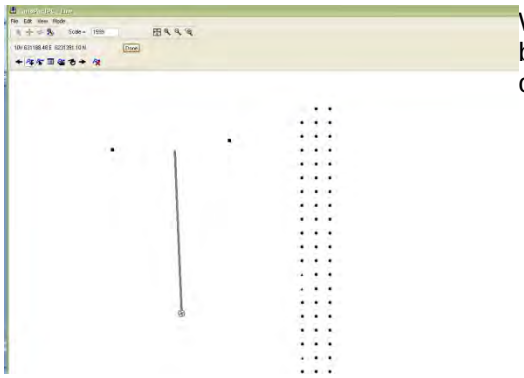
Write out the comment and tap “ok” to close form and return to main comment screen.



At the main comment screen, the comments can be reviewed or removed.



To add a line, tap the “+” button and select ‘line”. The screen will again go blank, waiting for the operator to draw the line (the line can be any length or shape, with vertexes added by double clicking).



When sample line is drawn click “done” and the form options box will appear. Note that for “line” subsurface test is not an option.

repeat same procedure for polygon.

5.0 IMAGERY

Imagery for the entire project area is pre-loaded onto the SD card of Trimble unit. There are six sets of imagery available:

- Orthophoto
- Orthophoto with the AOA model
- LiDAR Hillshade
- LiDAR Hillshade with the AOA model
- Topographic
- Topographic with the AOA model

Imagery can either be selected individually, or it can be auto-selected (recommended).

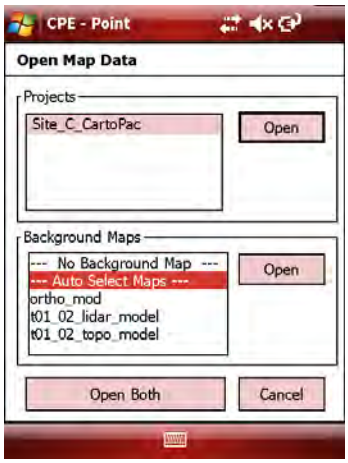


Figure 1. Maps can either be auto-selected, individually selected, or turned off completely as per the File>Open>Background Maps menu.

When Autoselect is used, the background imagery will be selected depending on the scale that the unit is zoomed into. The following table shows which maps show up at various scales when using the Autoselect function. See Figures 2-4 below for examples.

Image	**Scale Threshold (lower)**	**Scale Threshold (upper)**
Ortho – moderate resolution	20,000	100,000
LiDAR hillshade with model – high resolution	5,000	20,000
Topo (contours) with model	0	5,000

If an individual image is selected (i.e., autoselect is not engaged), it can be viewed at any scale, therefore user discretion is advised to prevent attempting to open high-resolution images at unsuitable scales (see Figure 5). The table below describes the naming conventions for the map sheets when looking for individual maps.

Txx_xx	tract number (e.g. t01_02 = tract 01-02 or the area between transects 01 and 02)
_*lidar*_model	LiDAR plus potential model
_lidar	LiDAR
_*ortho*_model	orthophoto plus potential model
_ortho	orthophoto
_*topo*_model	2m topography plus potential model
_topo	2m topography
So, for example: t01_02_topo_model = 2m topography plus potential model for tract 01-02	

Figure 2. Auto Select Maps – Ortho shows at scale 1:50,000

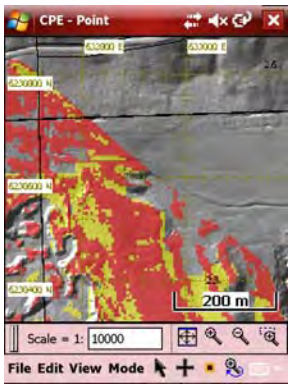


Figure 3. Auto Select Maps – Scale 1:10,000

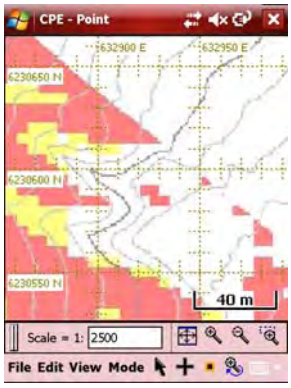


Figure 4. Auto Select Maps – Scale 1:2,500

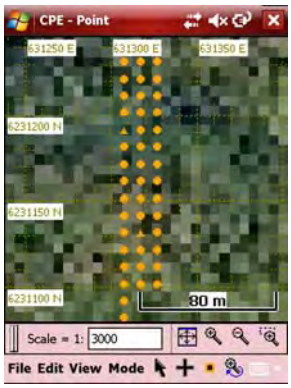


Figure 5. Individually selected map – shows up at all scales, including inappropriate scales such as this Orthophoto.

6.0 USING SLIDE TO UPLOAD AND DOWNLOAD FROM TRIMBLE

Detailed Workflow:

Downloading the Project from Remote Project Container

1. Open CartoPac Slide by selecting Start > Programs > CartoPac Field Solutions > CartoPac Slide.
2. Select Download then navigate to the remote project container (*.crpc) that contains your project and select Open.
3. Under Device Selection, make sure you select the correct device to download to.

   ActiveSync Device requires a connection to a mobile device and Local Machine will download projects to a user's computer.
4. Click Send to Device.
5. On the message, *Download Completed Successfully*, click OK.
6. CartoPac Tablet will open with your project.
7. Close CartoPac Slide.

Uploading the Project to Remote Project Container

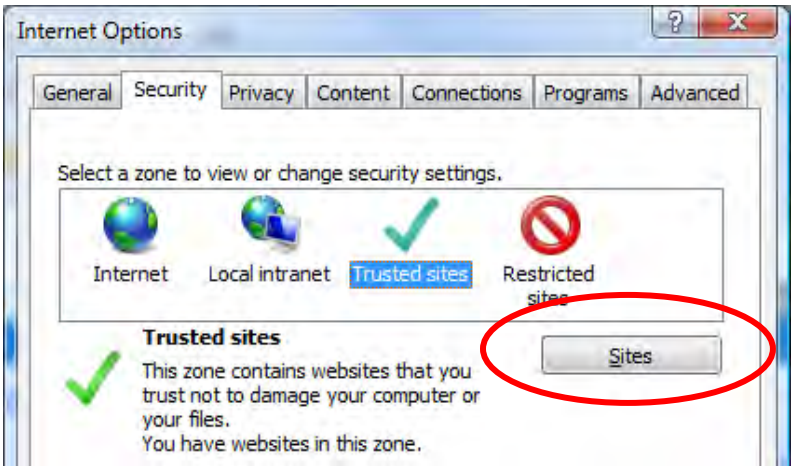
1. Open CartoPac Slide by selecting Start > Programs > CartoPac Field Solutions > CartoPac Slide.
2. Select Upload.
8. Under Device Selection, make sure you select the correct device to upload from.

   ActiveSync Device requires a connection to a mobile device and Local Machine will upload projects from a user's computer.
3. Make sure your project is under the name field then click Upload from Device.
4. Navigate to the location where you wish to save your remote project container (*.crpc) then select Save.
5. On the message, *Project Retrieved Successfully*, click OK.
6. Close CartoPac Slide.

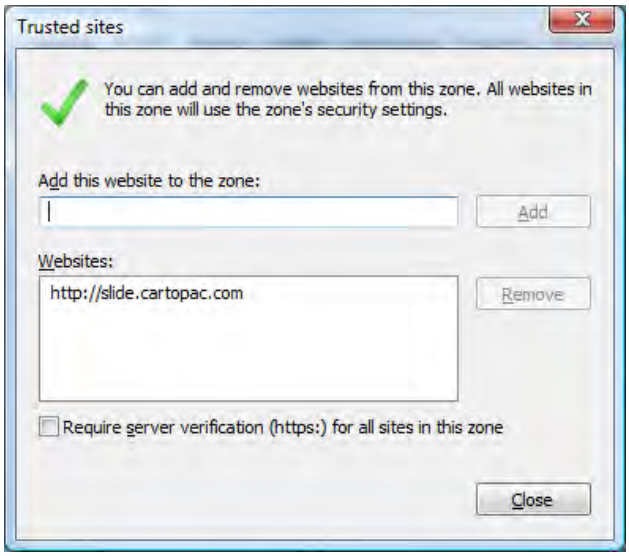
Installation Issues

If SLIDE isn't installing it may be due to the fact that http://slide.cartopac.com isn't a trusted site in internet explorer.

1. Open Internet Explorer.
2. Select Tools > Internet Options > Security.
3. Select Trusted Site, and then select the Sites button.



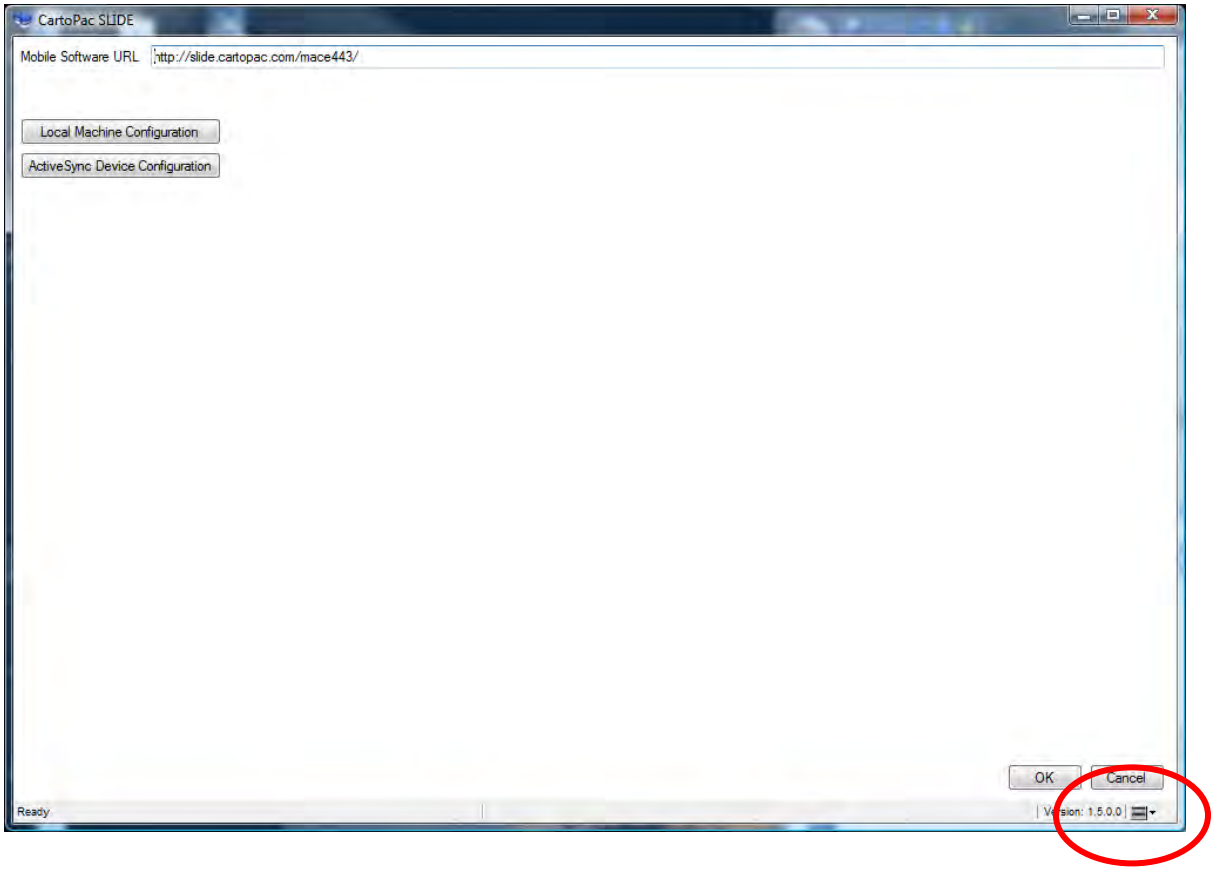
4. Uncheck the box next to Require server verification (https:) for all sites in this zone.
5. In the field under *Add this website to the zone:*, type in *http://slide.cartopac.com*. Then hit the Add button. *http://slide.cartopac.com* will appear in the box under *Websites:*



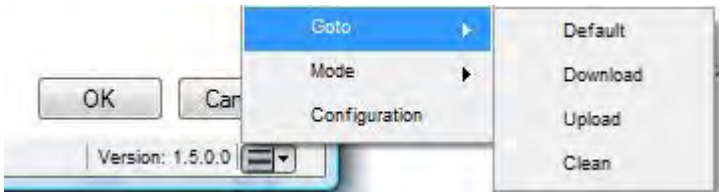
6. Tap Close to exit the Trusted sites dialogue box.
7. Click Apply, and then OK to exit Internet Options.

SLIDE Configuration

The configuration button is located at the bottom right of the SLIDE application.



Goto

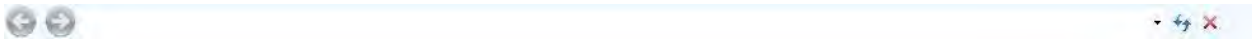


The Goto menu allows for navigation to individual slide locations.

Mode

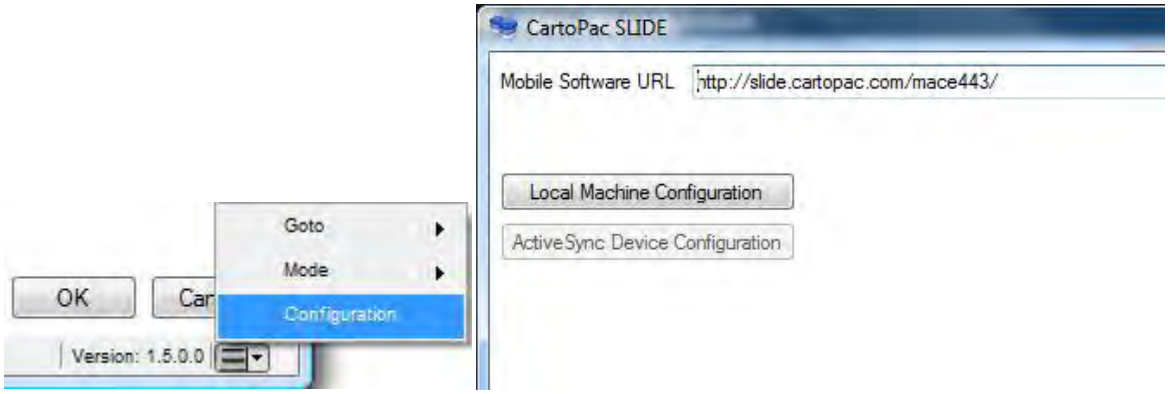
The Mode menu allows users to use SLIDE in either Internet Mode or Standalone Mode.

Internet Mode allows users to navigate to and perform all standard SLIDE functions using web addresses. In Internet Mode, the Navigation Bar can be toggled on and off depending on use.



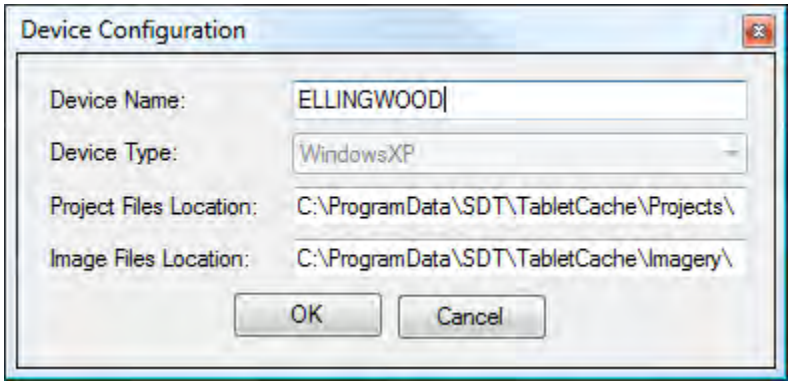
Standalone Mode allows users to perform all standard SLIDE functions using Remote Project Containers.

Configuration



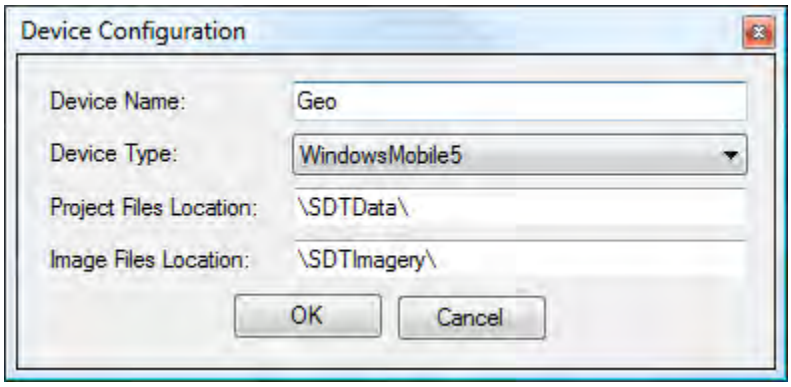
The Mobile Software URL shows the location and build of the CartoPac mobile software.

Local Machine Configuration



- Device Name - The current name of the local machine or desktop machine
- Device Type – The operating system of the local machine
- Project Files Location – The location of the project when downloaded
- Image Files Location – The location of the imagery or background maps when downloaded

ActiveSync Device Configuration



- Device Name – A name assigned to the mobile device
- Device Type – The operating system of the mobile device
- Project Files Location – The location of the project when downloaded
- Image Files Location – The location of the imagery or background maps when downloaded

Being able to set the project data and image file data locations to separate file paths has several advantages for field users. Users that have a large amount of imagery and maps can set the image file location path to a storage card on the device. Multiple projects can also be downloaded to a storage card and then accessed once in the field.

APPENDIX C

Palaeontological Site Significance Checklist

December 7, 2012
Report No. 12-1423-0008

Project:	Palaeontological Site Significance Evaluation Criteria		Positive Palaeo Site:		PS
			Yes	No	Ins
Scientific Significance	**I**	**Does the site contain evidence which may substantively enhance the scientific understanding of Palaeontology with regards to:**			
	I(a)	**Taxonomy?**			
	S1	Is the locality a previously published type-site for the palaeontological taxon?			
	S2	Is the locality a previously published topotype for the palaeontological taxon?			
	S3	Is the fossil an unknown taxon previously not described (possibly a new species)?			
	S4	Is the fossil a rare taxon useful as comparative material?			
	S5	Is the fossil a morphological variation to a known taxon?			
	S6	Is there enough material to allow a comprehensive description?			
	S7	Are there multiple sites to contribute to a broader understanding?			
	S8	Is it a unique fossil site?			
	S9	Are there other aspects not listed above? Please note.			
	I(b)	**Evolution?**			
	S10	Does the site represent an important stage or link demonstrating evolutionary relationships between known fossil phyla?			
	S11	Does the locality represent a new phylum (a group of related fossil taxa)?			
	S12	Does the locality represent a fossil occurrence that is previously unknown in the stratigraphic record?			
	S13	Is the site under-represented in the stratigraphic record?			
	S14	Are the fossils a rare phylum (usually of the more highly advanced types such as large vertebrates)?			
	S15	Does the site point towards new thoughts on evolutionary processes?			
	S16	Are there other aspects not listed above? Please note.			
	I(c)	**Biostratigraphy?**			
	S17	Does the site contain zonal index species useful for regional and/or interregional correlation?			
	S18	Does the site contain a zonal assemblage useful for regional and/or interregional correlation?			
	S19	Does the site contain stratigraphically restricted species (short ranging)?			
	S20	Does the site represent a new extended stratigraphic range?			
	S21	Does the site fill a stratigraphic gap in the taxon range?			
	S22	Does the site contain datable material in association with fossils (carbon in Pleistocene deposits/ash layers)?			
	S23	Is there good stratigraphic exposure and preservation for zonal definitions?			
	S24	Are there other aspects not listed above? Please note.			

Project:	Palaeontological Site Significance Evaluation Criteria		Positive Palaeo Site:		PS
			Yes	No	Ins
Scientific Significance (continued)	**I(d)**	**Palaeoecology?**			
	S25	Is the site useful for reconstructing palaeontological community structure?			
	S26	Is there a useful facies index species for reconstructing palaeontological community structure or habitat?			
	S27	Is there a useful facies assemblage for reconstructing sedimentary environments?			
	S28	Does the site contain a geographically restricted species (not ubiquitous)?			
	S29	Does the site represent a new extended geographic range?			
	S30	Does the site contain an unusual indicator or trace fossil showing living conditions (e.g., dinosaur tracks, coprolites)?			
	S31	Does the site fill a geographic gap in the taxon range?			
	S32	Are there other aspects not listed above? Please note.			
	I(e)	**Taphonomy?**			
	S33	Are fossil specimen(s) exceptionally preserved (vs. corroded or broken)?			
	S34	Are the fossil specimen(s) found in an unusual "living position" (*e.g.,* erect fossil trees)?			
	S35	Are the fossil specimen(s) *in situ* within stratigraphic context (vs. *ex situ* - reworked, slumped, in scree)?			
	S36	Are the fossil specimen(s) rarely preserved in the stratigraphic column?			
	S37	Are there unique geological phenomena?			
	S38	Are there other aspects not listed above? Please note.			
	I(f)	**Palaeontological Methodology?**			
	S39	Is there potential for experimentation aimed at improving palaeontological methods and techniques?			
	S40	Could the site contribute to other scientific disciplines (*e.g.*, archaeology, botany, zoology, geology, or glaciology)?			
	S41	Are there other aspects not listed above? Please note.			
Heritage Significance	**II (a)**	**Does the site contain palaeontological resources that have heritage value?**			
	H1	Is the site located within the boundary of a provincial park or other protected area?			
	H2	Are the fossils recognized by a community as important?			
	H3	Are the fossils recognized by First Nations as important?			
	II (b)	**Does the site currently receive visitation by tourists, local residents or school groups?**			
	H4	Is it a well-known site commonly visited by amateur palaeontologists?			
	H5	Is the site associated with a historical figure, organization, or early stage of fossil exploration?			
	H6	Is the site located near a fossil site notated as a World Heritage site?			
	II (c)	**Is the site a commonly acknowledged landmark?**			
	H7	Does it have geological significance (e.g., a type location for a formation)?			
	H8	Does it have geomorphological significance (e.g. hoodoos)?			
	H9	Are there other aspects not listed above? Please note			

Project:	Palaeontological Site Significance Evaluation Criteria		Positive Palaeo Site:		PS
			Yes	No	Ins
Educational Significance	**III (a)**	**Does the site contain palaeontological resources that have education value?**			
	E1	Are there quality fossil specimens desired by local or regional museums?			
	E2	Could the fossils be utilized for teaching purposes?			
	E3	Is the site presently utilized as a teaching site by institutions?			
	E4	Could the site be utilized as a teaching site by institutions?			
	III (b)	Does the site have potential for public use in an interpretive, educational or recreational manner?			
	E5	Is the site accessible to the public?			
	E6	Does the site have potential for public use as an interpretive setting?			
	E7	Is the locality representative or a unique fossil site?			
	E8	Are there other aspects not listed above? Please note			
Commercial Significance	**IV (a)**	**Does the site contain palaeontological resources that have commercial value?**			
	C1	Do the specimens have gem quality (e.g., ammolite from ammonites)?			
	C2	Do the fossil specimens have collector quality preservation (e.g. leaves and fish from McAbee Site)?			
	C3	Do the fossil specimens have an aesthetic quality (unusual preservation or associations)?			
	C4	Is there high fossil specimen abundance that could warrant "mining"?			
	IV (b)	**What value of user-benefits may be placed on the site?**			
	C5	Are visitors willing to pay to visit the site?			
	C6	Are visitors' travel costs significant?			
	C7	Is there the potential for enhancement of corporate or institutional image (i.e., goodwill)?			
	C8	Are there other aspects not listed above? Please note			
		Totals			
		Percentage			
		Certainty Percentage			

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APPENDIX D

Summary of Known Palaeontological Species by Geological Formation

December 7, 2012
Report No. 12-1423-0008

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Quaternary	N/A	Q1**, Q2, Q3a-b, Q4a-e, Q5, Q6,** Q7-Q9, **Q10, Q11, Q12-Q13, Q14, Q15, Q16, Q17, Q18,** Q19**, Q20, Q21**	Gastropods – undifferentiated *Amnicola limnosa* *Discus crokhitei* *Euconulus fulvus* *Fossaria parva* *Gyraulus ceircumstriatus* *Gyraulus deflectus* *Hawaiia minuscula* *Helisoma* *Physa jennessi* *Stangicola catascopium* *Stagnicola arctica* *Stagnicola elodes* *Succinea grosvenori* *Succinea avar* *Vallonia gracilicosta* *Valvata sincera helicoidea* *Valvata piligera yukonensis* *Valvata tricarinata* *Zonitoides arboreus* *Zonitoides nitidus?*	**Mammals** **Bison:** ***Bison* – certebra** ***Bison* – cranium** ***Bison* – phalanx** ***Bison* – vertebrae** ***Bison* –other skeletal element** **Birds:** ***Anatinae* – duck** ***Corvus corax* – raven** ***Hirundo pyrrhonota* – swallow** **Picadae – woodpecker** **Others birds** **Hares:** ***Lepus americanus* – snowshoe hare** ***Lepus* – unidentified** **Mammoth:** ***Mammuthus primigenius* – woolly mammoth** ***Mammuthus* – molars** ***Mammuthus* – tusk** ***Mammuthus* – other skeletal elements;** **Moose:** ***Alces alces* – tooth** **Sheep:** ***Ovis canadensis* – bighorn sheep** **Rodents:** ***Clethrionomys gapperi* – southern red-backed vole** ***Dicrostonyx torquatus* – Lemming** ***Marmota monax* – marmot** ***Microtus pennsylvanicus* – meadow vole** ***Microtus xanthognathus* – Yellow snout vole** ***Spermophilus* – ground squirrel** ***Peromyscus maniculatus* – deer mouse** ***Tamiasciurus hudsonicus* – red squirrel** **Wolf:** ***Canis*** Wapiti **Fish – unidentified**	**Wood and Charcoal** **Pollen and Spores**	Sternberg 1930; Mathews 1963, 1978a, 1978b, 1980; Rutter, et al.1972; Hume 1977; Churcher and Wilson 1979; Lowdon and Blake 1979; Clague 1980; Bobrowsky 1982; White and Mathews 1982; Driver 1988; Woolf 1993; Apland and Harington 1994; Driver, et al. 1996; Wilson 1996; Harington 2003; Shapiro, et al. 2004; Vallières 2004; Hartman 2005; Jull and Geertsema 2006; Hartman and Clague 2008; Hebda, et al. 2008; Wilson 2009

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Cretaceous (Fort St. John Group)	N/A	Dunvegan Formation **K1, K13,** K23, **K38,** K41-K43, **K44, K45, K105, K106, K109-K112,** K123, **K124,** K125, **K126,** K127, **K128, K129,** K130, K131, K132, **K133, K134, K135,** K136, K137, **K158, K198, K236-K239,** K244-K249, **K250, K251,** K252, K253, **K272, K274, K275, K286, K291, K301,** K307, K308	**Ammonites – indeterminate** Gastropods *Viviparus murrayensis*? **Pelecypods:** *Arctica murrayensis* *Corbicula* *Corbula subtrigonalisi?* *Nodiolus (brachydontes)* ***Inoceramus*** *Inoceramus dunveganensis* *Inoceramus mcconnelli* *Inoceramus fragilis?* *Melania?* *Monotis subcircularis* (reworked Triassic?) pectenids *Unio (Pleurobema) dowlingi* **pelecypods indeterminate**	Dinosaurs: *Columbosauripus ungulates* ichnites *Tetrapodosaurus* *Camptosaurus*? – vertebra and rib Tridactyous – ichnites **Fish:** **Fish scales – unidentified** Birds: Didactylous– swimming toe ichnites Tridactyous – ichnites	**Macroflora:** *Andromeda? spatula* *Araliaephyllum rotundiloba* *Aspleniium foersteri* *Cephalotaxopsis heterophylla* *Cladophlebis arctica* *Cladophlebis frigida* *Credneria truncatodenticulata* *Dryophyllum* *Elatocladus intermedius* ***Elatocladus smittiana?*** *Ficus daphnogenoides* *Grewia* *Grewiopsis?* *Hymenaea fayettensis* *Isoetites horridus* *Laurophyllum* *Liriodendron giganteum* *Magnolia hollicki?* *Magnolia magnifica* *Magnolia speciosa?* *Menisprmites reniformis* ***Metasequoia cuneata*** ***Nymphaeites exemplaris*** *Orchidaceae* *Palaeonuphar nordenskioedi* *Platanus affinis* ***Platanus latiloba*** *Podozamites* *Populites platanoides* *Protophyllum boreale?* *Protophyllum multinerve?* *Pseudocycas unjiga* *Pseudoprotophyllum boreale* *Pseudoprotophyllum latifolium* *Pseudoprotophyllum undulatum?* *Sassafras (Araliopsis)* *Sequoiites concinna* *Sphenopteris (Onychiopsis/) psiloides* *Sphenopteris stricta* ***Tapeinidium? undulatum*** *Trochodenroides potomacensis* *Viburum* *Widdringtonites reichi* **Amber – fossil resin** Plant bark Plant bark	Dawson 1881; Williams and Bocock 1932; Jeletzky 1956, 1957a, 1957b, 1958, 1961a; Irish 1958; Bell 1963, 1965a; McGregor 1960 as cited in Hughes 1967; Stott 1968; Storer 1975; Currie 1989; Royal Tyrrell Museum of Palaeontology 2010
Cretaceous (Fort St. John Group)	Shaftesbury Formation	Cruiser Formation (Upper Shaftesbury Formation equivalent) **K2-K3, K4-K6, K40, K91, K95, K96, K97, K103, K104, K108,** K159, K161, **K164, K173,** K181-K183, **K184, K185,** K194, K195, **K235, K243, K300**	**Ammonites:** ***Beudanticeras*** ***Beattonoceras beattonense*** ***Gastroplitides (Parangastroplites?) liardense*** ***Hoplites?*** ***Irenioceras bahani*** ***Neogastroplites americanus*** ***Neogastroplites cornutus*** ***Neogastroplites maclearni?*** ***Neogastroplites muelleri*** ***Stelckiceras liardense*** ***Pleurobema cruiserensis*** **Foraminifera – abundant and diverse:** ***Haplophragmoides gigas*** **Assemblage** ***Ammobaculites wenonahae*** **Assemblage.** **Pelecypods:** ***Goniomyon*** ***Inoceramus*** ***Inoceramus concentricus?*** **Oxytoma** **Pecten** ***Posidonia? nahwisi goodrichensis*** ***Posidonia? nahwisi*** **other indeterminate**	**Fish:** **Scales – unidentified**	Megaspores	Williams and Bocock 1932; Thorsteinson 1952; Greiner 1955; Irish 1955; Stelck, et al. 1958; Jeletzky 1961a; Stelck 1962; Hughes 1964; Stott 1979, 1982; Singh 1983

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Cretaceous (Fort St. John Group)	Shaftesbury Formation	Goodrich Formation (Middle Shaftesbury Formation equivalent) **K7-K12, K98, K63-K66, K91, K93-K95, K155-K157, K161, K170-K172, K178, K193, K241, K270, K271, K273, K278-K281, K283-K285, K287, K290, K292**	**Ammonites:** ***Beudanticeras?*** ***Gastroplites*** ***Neogastroplites?*** ***Neogastroplites cornutus*** ***Neogastroplites haasi*** ***Placenticeras lardense?*** **Bryozoans – undifferentiated** **Echinoderms:** **Starfish ichnites** **Foraminifera: *Haplophragmoides postis goodrichi* Subzone.** **Gastropods** **Campoloma?** **Pelecypods:** ***Anemia*** ***Arctica*** ***Corbula palliseri?*** ***Donax?*** ***Inoceramus?*** ***Inoceramus concentricus?*** ***Melania?*** ***Modiolus (Brachyodontes) flumensis?*** ***Ostrea*** ***Oxytoma camselli?*** ***Oxytoma pinania?*** ***Pholamya*** ***Posidonia nahwisi nahwisi*** ***Posidonia. nahwisi goodrichensis*** ***Pteria*** ***Tellina*** ***Protelliption*** ***Pleuromya kissoumi*** ***Tancredia stelcki*** ***Unio (Pleurobema)?***	ND	ND	Williams and Bocock 1932; Wickenden and Shaw 1943; McLearn and Kindle 1950; Jeletzky 1957a, 1957b, 1956, 1961a, 1970; Irish 1958; McLearn 1917 as cited in Jeletzky 1964; Stott 1968; Warren & Stelck 1969; Sutherland and Stelck 1972; Caldwell, et al. 1978; Stott 1979, 1982
Cretaceous (Fort St. John Group)	Shaftesbury Formation	Hasler Formation (Lower Shaftesbury Formation equivalent) **K14-K17, K19, K20, K35, K36, K70** K90 **K92** **K98, K138, K160, K162, K163, K165, K166, K167, K174-K176 K70, K177, K298**	**Ammonites:** ***Beudanticeras?*** ***Cleoniceras?*** ***Gastroplitides canadensis*** ***Gastroplitides cantianus*** ***Gastroplitides (Parangastroplites?) liardense*** ***Gastroplitides spiekeri?*** ***Lemaroceras belli?*** ***Lemaroceras mcconnelli?*** ***Neogastroplites haasi*** ***Neogastroplites haasi*** ***Neogastroplites selwini?*** ***Stelckiceras liardense*** **Bryozoans:** ***Gymnolaemata*** **Echinoderms:** ***Lophidiaster?* – starfish** **Stelleroidea – starfish** **Foraminifers – common and diverse** **Gastropods – undifferentiated** **Decapods:** **macruran *crustacean*** **Pelecypods:** ***Arctica?*** ***Inoceramus cadottensis?*** ***Inoceramus altifluminis?*** ***Monotis*** ***Nucula*** ***Ostrea*** ***Pectin (Entolium) irenense?*** ***Pinna*** ***Pleuromya*** ***Posidoniomya nahwisi*** **pelecypods – indeterminate** **Trace Fossils:** **Worm burrows**	**Coprolites – undifferentiated** **Fish:** **Scales – large and small, unidentified** **Bone elements – unidentified** ***Chontrichthyes* tooth**	**Macroflora:** ***Elatides splendid* – Taxodiaceae** **Diatoms:** ***Coscinodiscus***	Irish 1958; Jeletzky 1956, 1961a, 1970; Sutherland and Stelck 1972; Stott 1979, 1982; Koke and Stelck 1984; Legun 2003, 2005; Royal Tyrrell Museum of Palaeontology 2010

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Cretaceous (Fort St. John Group)	Shaftesbury Formation	Boulder Creek Formation **K46, K49, K51, K52, K56, K61,** K62, **K71-73, K74, K75, K87,** K88, **K89, K113-K116,** K117, K118, **K119, K120,** K121, **K122,** K140, **K151, K152, K168, K265,** K288, **K289, K294, -K296**	**Ammonites:** ***Gastroplites allani*** ***Gastroplites canadensis*** ***Gastroplites flexicostatus?*** ***Gastroplites kingi*** ***Gastroplites liardense*** ***Gastroplites spiekeri*** ***Neogastroplites cornutus*** ***Pseudopulchellia pattoni*** ***Pseudogastroplites?*** **Foraminifers – Cadotte Assemblage** **Gastropods – indeterminate** ***Echinoderms***: ***Lophidaster silentiensis?* – starfis** ***Pelecypods:*** ***Arctica*** ***Inoceramus*** ***Inoceramus anglicus?*** ***Inoceramus cadottensis?*** ***Pterotrigonia albertensis?*** ***Pectin IEntolium)*** *Unio dowlingi* **Pelecypods – indeterminate**	**Fish – unidentified** **Reptiles:**	Macroflora: *Artocarpidium cretaceum* *Cladophlephis frigida* *Cercidiphyllum* *Cinnamomoides newberryi?* ***Ficus glascoeana*** *Ficus ovatifolia* ***Ficus? fontainii?*** ***Fontainea grandifolia*** ***Laurophyllum?*** ***Magnolia lacoeana?*** ***Menispermites reniformis*** ***Menispermites potomacensis*** *Paliurus* *Plantanus* ***?Pseudocycas dedunkeriuna*** *Pseudocycas unjiga?* ***Protophyllum*** ***Pterophyllum validum*** *Pterophyllum plicatum* *Rhamnus.*	Wickenden and Shaw 1943; Bell 1956, 1965b; Stelck, et al. 1956; Jeletzky 1961a, 1969, 1970, 1980, 1987; Mellon, et al. 1963; Hughes 1967; McGregor 1960 as cited in Hughes 1967; Stott 1979, 1982; Wall 1988
Cretaceous (Fort St. John Group)	Shaftesbury Formation	**Hulcross Formation** **K47, K48, K50, K57, K58, K60, K68, K69, K85,** K139, **K150, K154, K169,** K197, **K267, K268, K269**	**Ammonites:** ***Arcthoplites*** ***Beudanticeras*** ***Beudanticeras/Cleoniceras?*** *Gastroplites allani* ***Gastroplites canadensis*** ***Gastroplites kingi allani* – possible synonym *G. allani*** *Gastroplites kingi kingi* ***Gastroplites kingi flexicostatum*** *Gastroplites liardene* ***Gastroplites spiekeri*** ***Gastroplites stantoni/flexicostatus*** ***Pseudopulchella pattoni*** Foraminifers – Abundant and diverse Coprolites – tentative identification **Echinoderms:** ***Lophidiaster selentiensis* – Starfish** **Gastropods – undifferentiated** **Pelecypods:** ***Arctica*** ***Inoceramus cadottensis altifluminis*** ***Modiolus?*** ***Ostrea*** ***Pecten (Entolium) irenense*** ***Pleuromya*** ***Pseudopulchellia patteni*** **Pelecypods – indeterminate**	ND	Diatoms: *Cypridea*	Jeletzky 1962a, 1969, 1970, 1980, 1985; Stott 1979, 1982; Hage as cited in in Stott 1982; Irish as cited in Stott 1982

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Cretaceous (Fort St. John Group)	Shaftesbury Formation	**Gates Formation** **K18, K21, K22, K54, K83,** K84, K37, K99, **K153, K156, K102,** K141, K142, **K143,** K144, K145, **K156, K186**, **K192, K234, K240, K264**	**Ammonites:** ***Arcthoplites irenensis*** ***Beudanticeras*** ***Beudanticeras affine****?* *Beudanticeras mcconnelli?* ***Cleoniceras****?* ***Gastroplitides canadensis*** ***Gastroplitides cantianus****?* ***Lemuroceras belli****?* ***Lemuroceras belli/indicum****?* ***Lemuroceras irenesnse*** ***Lemuroceras mcconnelli****?* **"Nautilus or Ammonite" – a mould** **Foraminifers- common and diverse** **Echinoderms:** **Starfish – *Lophidiaster*** **Crinoid – Sea lily** Gastropods – undifferentiated **Pelecypods:** ***Arctica*** ***Astarte portana*** ***Aucella?*** ***Camptonectes ?stygius,*** *Aucellina* *Inoceramus apicalis* ***Inoceramus dowlingi?*** ***Modiolus?*** *Murraia* ***Ostrea*** ***Oxytoma (Pteria)*** ***Pecten (Entolium) irenense*** ***Pleuromya*** *Protocardia alcensiana* ***Tancredia*** ***Tracia?*** *Unio* **Trace Fossils:** *Rhizocorallium* **Worm burrows**	**Dinosaur tracks (ichnites) – Abundant:** ***Amblydactylus*** Ceratopsidae **Irenesauripus** Theropods - undifferentiated *Tetrapodosaurus borealis* Birds: *Aquatilavipes swiboldae* *Aquatilavipes curriei* Mammals: *Tricorynopus brinkmani*	Macroflora - Blairemore-Luscar-Gething "Aptian" flora *Anthrotaxites berryi* Asteriadae (Sonanales) *Avaliaephyllym?* *Brachyophyllum* *Coniopteris brevifolia* *Cladophlebis purva* *Cladophlebis curvifolia* *Cladophlebis virginiensis* *Ctenis borealis* *Ctenopteris insignis* *Cypassidium?* *Dentalum* *Elatides curvifolia* *Elatocladus brevifolia* *Gleichinites giesekianus* *Gingoaceae* *Ginkgo pluripartita* *Carpites* *Nilssonia* *Onchipsis* *Phoenicopsis arcticus* *Perophyllium* *Pseudocycas* *Pterophyllum nordenskioldii* *Pityophyllum rectangular* *Ptilophyllum* *Sagenopteris* *Sapindopsis belviderensis* *Sequoia condita* *Sphenopteris latiloba* *Stenorachis* *Stephopteris* Megaspore: *Erlansonisporites* *Pyrobolospora* Charaophytes: *?Stellatochara* *Praechara* Seeds: *?Microcarpolithes*.	Whiteaves 1876; Dawson 1881; Williams and Bocock 1932; McLearn and Kindle 1950; Stelck, et al. 1956; Jeletzky 1957a, 1957c, 1970; Irish 1958; Mellon, et al. 1963; Stott 1968, 1979, 1982; Bell, Hueber an McGregor as cited in Stott 1968; Flynn, et al. 1976; Irish as cited in Stott 1982; Royal Tyrrell Museum of Palaeontology 2010; BC Hydro 2011
Cretaceous (Fort St. John Group)	Shaftesbury Formation	Moosebar Formation **K22,** **K148, K53, K59, K76, K77, K78,** K79, K80, K81, **K82, K86,** K146, K147, **K148,** K149, K196, **K200, K201, K202a, K202b, K206, K203b, K203b, K204, K205, K207, K208, K209, K266, K277,** K293, **K297, K299**	Ammonites: *Arcthoplites aptiensis* ***Arcthoplites (Lemuroceras) indicum?*** ***Arcthoplites (Freboldiceras) irenense*** ***Arcthoplites belli/A. indicum?*** ***Arcthoplites ireniense*– synonym?** ***Lemuroceras irenese?* – synonym?** ***Subarctoplites irenense* – synonym?** **Echinoderms:** **starfish – unidentified** **Foraminifers – abundant and diverse** Ostracods: *Cytherella?* *Heterocypris?* *Metacypris* *Paracypridea?* Pelecypods: *Aucellina aptiensis* ***Camptonectes*** *Cyzicus* *Dentalium* ***Inoceramus cadottensis?*** ***Lima*** ***Pecten (Entolium)*** ***Pecten (Pseudomussium?)*** *Pleuromya* **Pelecypods – indeterminate**	**Fish:** teeth bone elements	Diatoms Megasporangia type 1A-5 Radiolaria *Dictyomitra*	McLearn and Kindle 1950; Stelck, et al. 1956; Jeletzky 1957b, 1961a, 1962a, 1970; Warren and Stelck 1960; Mellon, et al. 1963; Chamney 1964; Stott 1979, 1982; Jeletzky as cited in Stott 1982; Wall as cited in Stott 1982; Wall 1983, 1984a

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Cretaceous (Fort St. John Group)	Bullhead Group	Gething Formation (Luscar Formation) **K24-K34,** K55, K99, **K101, K210, K211,** K212-K214, **K215-K219, K221-K233, K254, K282, K302,** K309-396	**Ammonites:** **Gastroplitids** **Belemnites:** Belemnoids – unidentified Echinoderms: Crinoids **Gastropods:** *Viviparus* Foraminifers: - diverse and abundant Ostracods: *Cypridea* *Cytheridea* *Darwinula* *Metacypris?* *Qpridea* *Saxocythere* **Pelecypods** ***Astarte****?* *Aucellina aptiensis* ***Corbicula*** *Corbicula occidentalis?* *Corbicula subtrigonalis?* *Corbicula parundata?* *Corbicula nematophora?* *Discranodonta* *Goniobiasis?* *Inoceramus* ***Nactra****?* ***Pecten (Entolium)*** *Pecten (Entolium) irenense?* ***Tellina****?* ***Thracia?*** ***Unio****?* Sponge spicules **Trace Fossils:** **Annelida (worm) traces**	**Fish:** **Teeth – unidentified** **Reptiles:** **Dinosaur tracks (ichnites):** ***Amblydactylus gethingi*** ***Amblydactylus kortmeyeri*** ***Columbosauripus ungulates*** ***Gypsichnites pacenses*** **Hadrosaur ichnites** ***Irenesauripus mclearni*** ***Irenesauripus acutus*** ***Irenesauripus gracilis*** ***Irenesauripus occidentalis*** ***Tetrapodosaurus borealis***	**Macroflora:** *Archostichopteris foliosa* ***Athrotaxites berryi*** ***Baiera gracilis?*** ***Cladophlebis parva*** ***Cladophlebis strictinervis*** ***Cladophlebis virginiensis*** *Coniopteris berryi* ***Coniopteris brevifoilia*** *Ctenis* ***Ctenopteris insignis*** *Cycadopsida* ***Elatocladus acifolia*** ***Elatides curvifolia*** ***Elatides latilobata*** ***Elatides splendida*** ***Equisetum lyelli*** ***burchardti*** *Gleichenites giesekianus* *Gleichenites nordenskoildi* ***Ginkgo pluripartita*** *Klukia canadesis* *Metasequoia? smittiana* *Nilssonia brongniarti* *Nilssonia california* ***Nilssonia canadensis*** ***Nilsonnia yukonensis*** *Onychiopsis psilotoides* *Pagiophyllum magnifolium* Charophytes: *Charaxis* *Clavatoraceae* ***Praechara*** ***Sphaerochara*** *Stellatochara mundula* Diatoms: *Coscinodiscus* Radiolarians – unidentified Seeds: *Microcarpolithes* **Spores and pollen - abundant** ***Phoenicospis angifolia media*** *Phyllites* ***Pityophyllum arcticum*** *Pityophyllum longifolium?* ***Pityophyllum nordenskoildi?*** ***Podozamites lanceolatus*** *Pseudocycas dunkeriana* *Pseudocycas unjiga?* ***Pterophyllum arcticum*** ***Pterophyllum plicatum*** ***Pterophyllum rectangulare*** *Pterophyllum validum?* ***Ptilophyllum montanense*** *Sagenopteris mclearni* ***Sagenopteris williamsi*** *Sapindopsis belviderensis* *Selaginellites* *Sphenopteris brulensis* ***Sphenopteris goepperti*** ***Sphenopteris latilobata*** *Sphenopteris lyelli burchardti* *Sphenopteris (Gleichenites?) erecta* *Stenoarchis striolatus* ***Thallites blairmorensis*** ***Tree trunk – well preserved*** *Zamites*	Dawson 1881; Sternberg 1932; Beach and Spivak 1944; Beach 1942 as cited in Bell 1956; Bell 1956, 1965b; Dowling 1911 in Bell 1956; Erdman 1946 in Bell 1956; McKay 1919, 1924, 1927, 1928, 1929 as cited in Bell 1956; McLearn 1937 as cited in Bell 1956; McLennan 1915 as cited in Bell 1956; Speaker 1940 in Bell 1956; Sternberg 1930 in Bell 1956; Stewart 1916 in Bell 1956; Jeletzky 1957b, 1957c, 1961b, 1961c, 1962a, 1981a; Hughes 1964; McGregor 1960, 1961 as cited in Hughes 1964, 1967; McMechnie 1956 in Hughes 1964; Stott 1973, 1979, 1982; Wall 1978, 1983, 1984b; Currie and Sarjeant 1979; Legun 1983; Currie 1989; Royal Tyrrell Museum of Palaeontology 2010

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Cretaceous (Fort St. John Group)	Bullhead Group	Cadomin Formation **K219, K220, K302,** K303-K306	**Pelecypods:** *Cardium peoperculum?* *Exogyra auborbiculata* *Ostrea*	ND	***Athrotaxites berryi*** ***Elatides curvifolia*** ***Elatides splendida*** ***Pityophyllum nordenskiijldi?*** ***Podozamites lanceolatus?*** ***Pterophyllum plicatum*** ***Pterophyllum rectangulare***	Jeletzky 1957c, 1962a, 1986; Hughes 1964; McGregor 1960, 1961 as cited in Hughes 1964
Cretaceous (Fort St. John Group)	Minnes Group	Bickford Formation **K512**	**Trace Fossils:** ***Diplocriterion*** **Gastropod? grazing trails** ***Skolithos*** ***Trichichnus***	ND	root casts with thin coal seams	Legun 1988
	Minnes Group	Monach Formation **K404a,b, K411, K416, K418, K421, K422, K449, K450, K452, K461, K462, K463, K481, K482, K486, K501, K503**	**Ammonites:** ***Dichotomites giganteus*** ***Homolsomites*** ***Tollia (Subcraspedites?)*** ***Polyptychites (Polyptchites)*** **Ammonites - indeterminate** **Belemnites – unidentified** **Brachiopods:** **Pelecypods:** ***Buchia inflata*** ***Buchia crassicollis SOLIDA?*** ***Buchia keyserlingi*** ***Buchia pacifica*** ***Buchia uncitoides***	ND	ND	Jeletzky 1961d, 1962a, 1970, 1982a; Hughes 1967
	Minnes Group	Beattie Peaks Formation **K403a,b, K405, K409, K415, K417, K419, K420, K423-K429, K439-K448, K451, K458, K459, K464, K466-K472, K474-K477, K479, K480, K483, K484, K487, K489-K493, K502, K508- K510, K511**	**Ammonites:** ***Dichotomites quatsinoensis*** ***D. oregonensis*** ***Neocomites (Odontodiscoceras?)*** ***Polyptychites (Polyptychites) keyserlingi*** **holcostephanids;** **Belemnites:** ***Acroteuthis*** **Echinoderms:** **crinoid stems** **ophiuroid (brittle star);** **Pelecypods – diverse and abundant** ***Arctica*** ***Buchia inflata*** ***Buchia bulloides*** ***Buchia keyseringi*** ***Buchia sublaevis*** ***Buchia terebratuloides*** ***Buchia tolmatschowi*** ***Buchia uncitoides*** ***Buchia unschensis*** ***Buchia volgensis*** ***Buchia Bulla (Tornatina)*** ***Camptonectes (Boreionectes)*** ***Camptonectes (McLearnia?)*** **corbiculids** ***Dentalium*** ***Inoceramus*** ***Oxytoma*** ***Pecten (Entolium)*** ***Pleuromya*** ***Tellina.***	**Dinosaurs: (From the "Minnes Formation")** **Theropods small – unidentified tracks** **Large biped – unidentified tracks**	ND	Jeletzky 1957b, 1959, 1961d, 1961e, 1962a, 1970, 1981b, 1981c, 1982a, 1982b, 1985; Hughes 1967; Currie 1989

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Cretaceous (Fort St. John Group)	Minnes Group	Monteith Formation **K400-K402, K408, K410, K412, K413, K430-K438, K453-K457, K460,** K478, **K485, K488, K500, K504- K506, K508, K512**	**Ammonites:** ***Craspedites (Tollia?) hoeli*** ***Polyptychites polyptychus?,*** ***Tollia (Subcraspedites) stenomphata*** ***Tollia (Subcraspedites) suprasubdita?*** **craspeditieds other** **Belemnites:** **Belemnidea – unidentified** **Pelecypods** ***Arctica*** ***Buchia inflata*** ***Buchia keyseringi*** ***Buchia okensis*** ***Buchia sublaevis?*** ***Buchia terebratuloides*** ***Buchia uncitoides*** ***Buchia unschensis*** ***Buchia volgensis?*** ***Dentalium*** ***Lima (Limea)*** *Ostrea* ***Oxytoma?*** ***Pecten (Entolium)*** ***Pecten (Pseudomassium?)*** ***Pholadomya?*** **Indeterminate forms**	ND	**Plant debris**	Jeletzky 1961d, 1962a, 1970, 1982a, 1982b; Hughes 1967; Currie 1989
Jurassic	Fernie 'Group'	Transition Beds and Upper Fernie Formation **J2, J5,** J7, J8, J15-J18, J21, J22, **J37**, J39, J41- J46, **J47, J48,** J49, J50, **J52,** J54-J57, J60, **J62,** J63, **J64-J66, J68-J71, J73, J74**	**Ammonites:** *Cardioceras (Scarburgensis) alphacordatum* *Cardioceras mountjoyi robusta* *Goliathiceras crassum?* *Gryphaea nebrascensis* *Craspedotes (Taimyroceras) canadensis?* *Pavlovia?* **Belemnites:** *Cylindroteuthis (Arctoteuthis) baculus?* Brachiopods: Rhynchonellids Echinoderms: *Pentacrinites*? *Pentacrinus* – sea lily **Gastropods – undifferentiated** **Pelecypods:** ***Arctica?*** ***Aucella schmidti*** ***Buchia mosquensis*** ***Buchia fischeriana*** ***Buchia piochii*** ***Buchia concentrica*** *Buchia russiensis* ***Buchia terebratuloides subinflata*** *Buchia tolmatschowi* ***Buchia uncitoides*** ***Buchia volgensis*** ***Camptonectes precinctus?*** ***Camptonectes (Boreionectes)*** ***Cucullaea?*** *Dentalium?* ***Ditrupa?*** ***Entolium*** *Goniomya* ***Lima (Limea?) blackei?*** ***Lima (Limatula) consabrina?*** ***Lima (Pseudolimea) arctica?*** ***Lima stantoni?*** ***Meleagrinella*** ***Modiolas*** ***Oxytoma*** ***Pecten (Entolium)*** ***Pectenids*** ***Pleuromya cardissoidiformi,*** ***Pleuromya dubois?*** ***Pleuromya galathea?*** ***Pleuromya panapeformis?*** ***Pleuromya postcuminata?*** ***Pleuromya rugosa?*** ***Pleuromya submissornata?*** ***Pholadomya?*** ***Thracia*** **Pelecypods – indeterminate**	Fish**:** *Chimaerotheca* **Reptiles:**	Wood fragments - undifferentiated	Stelck 1941 as cited in Mathews 1946; Langston 1959; Jeletzky 1961d; 1962b; 1971; 1981b; 1981c; 1982a; Hughes 1964; Neuman and Wilson 1985

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Jurassic	Fernie 'Group'	Mid' Fernie **J4,** J19, J20, J33a,b, J34, J59, J61, **J67**	**Ammonites:** *Arctocephalites (Cranocephalites) costus* *Arctocephalites multicostatus* *Atractites* *Cobbanites talkeetnanus* *Dubium* *Epizigzagiceras evolutum* *Iniskinites martini?* *Iniskinites robustus* *Iniskinites tenasensis* ***Kepplerites (Seymourites)*** *Kepplerites (Seymourites) ingrahami?* *Kepplerites (Seymourites) chisikensis?* *Lilloettia abruptus?* *Lilloettia lilloetensis* *Morrisiceras?* *Oppelia nites ubterneduys?* *Parareineckia shelikofana?* *Perisphinctids* *Xenocephalites vicarius* *Xenocephalites hebetus* Brachiopods: *Rhynchonellids* Pelecypods: *Arctica?* *Avicula?* *Buchia concentrica* *Inoceramus* *Lima (Pseudolimea) arctica?* *Pectinids* *Pleuromya cardissoidiformis* *Pleuromya rugosa?* *Pelecypods indeterminate*	ND	ND	Frebold, et al. 1959; Jeletzky 1971, 1982a; Frebold 1978
Jurassic	Fernie 'Group'	Lower Fernie Formation: **J1, J3, J36,**	**Ammonites:** *Leioceras* ***Psiloceras (Caloceras?)*** ***Psiloceras (Paraphylloceras) capilliphyllum*** Sonniniids Stephanoceratids *Xenocephalites* Belemnites: *Conodicoelites keeuwensis?* *Dicoelites?* *Haugia* **Brachiopods:** ***Furcirhynchia*** ***Furcirhynchia striata*** ***Homeorhynchia?*** ***Orbiculoidea (Discina)*** ***Rhynchonella furcillata?*** ***Rhynchonellid*** Echinoderms: *Pentacrinites* *Seirocrinus* **Gastropods** ***Pleurotomaria bovealis*** **Pelecypods** ***Camptochlamys*** ***Cardiania*** **Chlamys mcconnelli?** ***Chlamys textorius?*** ***Cucullaea*** ***Entolium clavum?*** ***Gryphaea*** ***Oxytoma*** ***Oxytoma inequivalvis?*** ***Oxytoma kiparisovae?*** ***Oxytoma monnelli?*** ***Pecten*** **Ostreids** ***Pleuromya?*** ***Trace Fossils:*** ***Small worm ichnites***	Fish – unidentified Reptiles: ichthyosaurs plesiosaurs	Plants - unidentified	Stelck 1941 as cited in Mathews 1946; Westermann 1962; Hughes 1967; Jeletzky 1980, 1981c, 1982a; Tozer 1967 as cited in Tozer 1982; Tozer 1982; Poulton, et al. 1990; Hall 1991; Orchard, et al. 2001
Triassic	Schooler Creek Group	Bocock Formation	Conodonts	ND	ND	Orchard as cited in Tozer 1982

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Triassic	Schooler Creek Group	Pardonet Formation T2- T5, T13, T14, T16-T24, T26, T29, T30-T35, **T38, T45,** T46, T47, T48, T49, T50, **T51, T52,** T53, T56, T60-T62, **T63**, T64-T66, T71-T77, **T78-T83,** T84- T86	**Ammonites:** *Anatropites* *Arcestes* ***Choristoceras kellyi?*** *Cleonites ares* group *Curviceras* ***Clydonautilus*** *Cyrtopleurites bicrenatus* *Dimorphotoceras caurinum* *Discotropites actitus (Moajsisovics)* *Distichites canadensis* *Distichites palliseri* *Distichites gethingi* *Distichites mesacathus?* *Drepanites* *Drepanites rittherfordi* *Eosteinmannites orientalis* *Episculites teres* ***Helictites decorus?*** *Helictites decorus transitionis* *Helictites decorus obesus* *Herclites exquisitus?* *Helictites subgeniculatus* *Himavitites appinatus* *Himavatites burlingi* *Himavatites columbianus* *Himavaties multiauritus* *Himavatites watsoni?* *Isculites browni* *Isculites corpulentus* *Isculites ornatus* *Isculites teres* ***Juvavites*** *Juvavites bococki* *Juvavites biornatus* *Juvavites carlottensis?* *Juvavites clavatus* *Juvavites custi* ***Juvavites kellyi*** ***Juvavites magnus,*** *Juvavites mertoni* *Juvavites makenzii* *Juvavites (Anatomites) edithae?* *Juvavites (Anatomites) humi* *Juvavites (Dimorphites?) pardonetiensis* *Juvavites (Gonionotites) gethingi* *Juvavites (Gonionotites) rarus* *Juvavites (Gonionotites) spiekeri?* *Juvavites (Griesbachites) selwyni* *Juvavites (Malayites) antipatris?* *Juvavites (Malayites) parcus* *Leiodistichites ursidens* ***Lissonites canadensis*** *Malayites dawsonii?* *Mesohimavitites columbianus* ***Metasibirites*** ***Paraguembilites ludingtoni*** *Paragymnites symmetricus* *Parajuvavites canadensis* *Parathisbites oineus* *Phormedites juvavicus?* *Pinacoceras* *Placites polydactylus* *Primapsiloceras?* ***Proclydonautilus natosini*** *Pseudaetomoceras* *Pseudosirenites pardoneti* *Pseudosirenites pressus* *Psiloceras calliphyllum* ***Rhabdoceras suessi*** ***Sagenites****?* *Schlotheimia* *Steinmannites?* *Sirenites columbianus* *Sirenites inaequiornatus* *Sirenites vredenburgi?* *Sirenites nabeschi* *Sirenites pardoneti* *Sirenites pressus* *Stikinoceras kerri* *Stikinoceras robustum* *Stryites ireneanus* *Styrites columbianus* *Thisbites* *Tropites*	**Bone fragments – unidentified** **Fish – unidentified** **Vertebrae – unidentified** **Bone fragments of marine reptile** Ichthyosaurids – vertebra Thalattosaurs Archosaur	**Fossil plants – unidentified, abundant**	Selwyn 1877; McLearn 1920, 1937, 1940, 1941, 1946, 1947; Williams and Bocock 1932; Warren 1945; Westermann 1962; Hughes 1967; Westerman and Verma 1967; Tozer 1967 as cited in Tozer 1982; Tozer 1982; McGowan 1991, 1994, 1995, 1997; Storers 1991; Zonneveld, et al. 1997; Nicholls, et al. 1998; Nicholls and Manabe 2001, 2004; Orchard, et al. 2001; Amati, et al. 2004; Ferri 2009; Zonneveld, et al. 2010; McRoberts 2011

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Triassic	Schooler Creek Group	***Cont'd*** Pardonet Formation T2- T5, T13, T14, T16-T24, T26, T29, T30-T35, **T38, T45,** T46, T47, T48, T49, T50, **T51, T52,** T53, T56, T60-T62, **T63**, T64-T66, T71-T77, **T78-T83,** T84- T86	**Brachiopods:** ***Avicula*** ***Dielasma*** ***Furcirrhynchia striata,*** ***Lingula*** *Piarorhynchia winnemae* ***Rhynchonella*** *Spiniferina* **Conodonts:** *Epigondolella bidentata.* **Echinoderms:** **Echinoids** – undifferentiated **Crinoids** – stems **Starfish** – undifferentiated **Gastropods – undifferentiated** **Pelecypods – undifferentiated** *Agerchlamys* *Alysidioptera? fomicata* ***Anodontophora griesbachi?*** *Asoella ireniana* *Buchites custi* *Buchites dawsoni* *Bucites ireneanus* *Buchites modestus?* ***Cardita cloacina*** ***Cardinia regularis?*** ***Chlamys nihanianus?*** ***Chlamys textoris?*** ***Entolium calvum?*** ***Eomonitis jakutica*** *Eomonotis obtusicostata* ***Eomonotis pinensis*** ***Gervillia goldfussi?*** ***Gryphaea arcutaeformis*** *Gryphaea chakii* *Halobia austrica* *Halobia beyrichi* ***Halobia cordillerana*** *Halobia dilatata* *Halobia fallax?* ***Halobia halorica*** *Halobia ornatissima* ***Halobia pacalis*** *Halobia radiata* *Halobia selwyni* *Halobia septentrionalis* ***Lima napii*** ***Lima? poyana*** *Lima? poyana Assemblage* *Lyriochlamys otianus* ***Meleagrinella mclearni*** *Monotis alaskana* ***Monotis jakutica*** ***Monitis ochotica denistriata*** ***Monitis ochotica ochotica*** ***Monitis ochotica posteroplana*** ***Monitis callazonensis*** ***Monitis subcirularis*** ***Monotis typica?*** ***Meleangrinella antiqua*** ***Chlamys nihanensis*** ***Monotis ochotica*** ***Monotis (Entomonotis) posteroplana*** ***Monotis (Pactimonotis) callazonensis*** ***Myophoria*** *Ostrea?* *Otapiria norica* ***Oxytoma ingequavalvis?*** *Oxytoma muronata?* *Pecten dishinni* *Pecten nihannianus* *Pecten sersianus* *Pleuromya nidovana* ***Praechlamys*** ***Pteria*** ***Shafhaeutlia mellingi?*** ***Terebratula julica?***	***Cont'd***	***Cont'd***	***Cont'd***

Age	Stratum	Sub-stratum (with Site Indices*)		Known Species			References
				Invertebrates	Vertebrates	Plants	
Triassic	Schooler Creek Group	Ludington Formation T10, T12, T15, T16, T28, **T38b**, **T39**, **T40a, T40b, T42-T44**, T57, **T58**, T60b, T68-T70	Baldonnel Formation Ducette Formation Charlie Lake Formation	**Ammonoids:** Arcestids *Discotripites* *Lotties pacianus* *Meginoceras* *Nathorstites mcconnelli* *Nitanoceras selwyni* *Protrachyceras sauwae* *Proirachyceras sikanianum* *Sayenites gethingi* *Silenticeras haiae* *Simmies (Meginoceras) megini* *Sirenites* **Brachiopods:** *Coenotheris peiriana* *Coenothris silvana* ***Dieslasma (Terebratula) julica?*** ***Lingula selwyni?*** **Rhynchonellids** *Spiniferina onsctae* **Conodonts:** *Metapolyanthus* **Decapods:** Lobsters – unidentified *Cruziana* – large trace fossils **Enchioderms:** **Crinoids – unidentified** **Gastropods – unidentified** **Pelecypods:** ***Bittneri*** *Cardium? saxitilis* ***Cassianella?*** *Daonella nitanae* *Gervillia bennetti?* *Halobia austrica* *Halobia ornatissima* *Halobia radiata* *Halobia selwyni* ***Halobia tozeri*** *Hoemesia woyaniana* *Hoernesia?* ***Lima poyana*** *Lima (Limatula) childerhosi* ***Modiolus*** *ahsisi* *Monotis montini* *Myalina williamsi* *Myoconcha curionii chenekai* *Mycoconcha curionii montipetraea* ***Myophoria*** *Mytilus ostiosus* *Orbiculoidea* *Ostryea* *Palaeocardita glaukos* *Palaeocardita nemoralis* *Parallelodon (Beushasenia)* *Pecten sasuchan* *Pinna* *Pleuromya* *Pleurophorus kissoumi* ***Pteria? aviculo*** ***Septocardia (?Pascoella)***	Reptiles: Marine reptilian bones	ND	Williams and Bocock 1932; McLearn 1937; McLearn as cited in Mathews 1946; McLearn 1941 as cited in McLearn 1947; McLearn 1947; Westermann 1962; Hughes 1967; Zonneveld, et al. 2002; McRoberts 2011
			Liard Formation	**Brachiopods:** **Lingulids** **Terebratulids** **Spiriferids** **Echinoderms:** **Echinoids** **Crinoids** **Gastropods – undifferentiated** **Decapods:** **Lobsters** **Lobster ichnites** **Pelecypods – undifferentiated**	**Fish – unidentified** **Reptiles:** **bone – unidentified** **Ichthyosaurids**	ND	Zonneveld, et al. 1997; Amati, et al. 2004
	Diabler Group	Toad Formation & Grayling Formation T54		ND	Fish: *Arcrolepis* *Coelacantus* *Elonichthys* *Lambeichthys* *Platysomus* *Saurichthys*	ND	Langston 1959

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Carboniferous	Stoddart Group	Taylor Flats Formation/ Kiskatinaw Formation **P01,** P02, P03, P04, P05, P06, P07, **P08, P09**	**Brachyopods:** ***Camarotoechia purduei laxa,*** ***Chonetes variolata*** *Dictyoclostus semireticulatus* *Dictyoclostus coloroadoensis* ***Dielasma*** *Dielasma arkensanum* *Jurasania nebrascensis* ***Linoproductus?*** ***Neospirifer*** *Orbiculoidea arenaria* ***Productus*** *Paraphorhynchus obscurum* *Phricodothyris perplexa* ***Punctospirifer*** ***Schellwienella*** ***Seminula eminula argentia*** *Schuchertella* ***Spirifer rochymountanus*** ***Spirifer solidirostris*** ***Spiriferella*** ***Squamularia?*** ***Waagenoconcha*** **Bryozoans:** **Fenestellid** **Undifferentiated** **Echinoderms:** **Crinoid stems – undifferentiated** **Corals:** ***Amplexizaphrentis*** *Caninia torquia* ***Diphyllum*** ***Lophophyllidium?*** ***Menophyllum ulrichanum*** ***Zaphrentis*** **Crinoid stems – undifferentiated** **Organic pellets – undifferentiated** **Gastropods:** *Euconospira turbiniformis* **Undifferentiated** **Mollusks – undifferentiated** **Pelecypods:** *Bakewellia parva* *Deltopecten occidentalis latiformis* *Myalina wyomingensis* **Undifferentiated**.	Fish: Skeletal elements	**Spores and pollen**	Williams and Bocock 1932; Warren 1956; Rutgers 1958; Halbertsma 1959; Langston 1959; Irish 1963
Carboniferous	Rundle Group	Golata Formation M16,M17, M19	Brachiopods: *Amplexizaphrentis* pilata? *Archimedes* *Camarotoechia metallica?* *Choristites?* *Dictyoclostus* *Leiorhynchus* *Linoproductus ovatus* *Marginifera* *Spirifer keokuk?* *Spiriferina leidyi?* Corals: *Ekvasophyllum inclinatum* *Syringopora* Pelecypod: *Deltopecten*	ND	Spores and pollen	Halbertsma 1959; Irish 1963

Age	Stratum	Sub-stratum (with Site Indices*)	Known Species			References
			Invertebrates	Vertebrates	Plants	
Carboniferous	Rundle Group	Prophet Formation M08-M15 M20-M29 M02, M03, M05, M08, M09, M10, M11, M12, M13, M14, M15, M18, M19, M20, M21, M22, M23, M24, M25, M26, M27, M28, M29, M31	Brachiopods: *Athryis* *Brachythris burlingtonensis* *Brachythris chuteauensis* *Camarotoechia* *Cleiothridina* *Composita* *Dictyoclostus inflatus var. coloradoensis* *Derbya* *Dielasma schumandanum* *Echinoconchus biseriatus?* *Leiorhynchus carboniferum* *Marginifera adairensis* *Neospirifer* *Orthotetes* *Platyrachella rutherfordi* *Productella* *Punctospirifer transversa?* *Reticularia pseudolineata* *Schellwienella* *Setigerites altonensis* *Spirifer arkansanus* *Spirifer cameratus* *Spirifer lateralis?* *Spirifer minnewankensis* *Spinifer greenockensis* Bryozoan – fenestellid Corals: *Amplexizaphrentis enniskilleni?* *Cayathoclisia* *Ekvasophyllum banffense* *Ekvasophyllum cascadense* *Ekvasophyllum enclinotabulatum* *Ekvasophyllum harkeri?* *Ekvasophyllum inclinatum* *Ekvasophyllum multiseptatum* *Ekvasophyllum turbineum* *Faberophyllum languidum* *Faberophyllum leathamense* *Faberophyllum pisgahaense* *Faberophyllum araneosum* *Kakwaiphyllum dux* *Koninckophyllum* *Litostrotion arizelum?* *Lithostrotion genevievensis* *Lithostrotion (Siphonodendron) sinnosum* *Lithostrotion (Siphonodendron) whitneyi* *Lithostrotionella banffensis* *Pseudozaphrentoides burling?* *Siphonophyllia virginica?* *Syringopora* *Triplophyllites* *Vesiculophyllum (Kakwiphyllum) dux?* *Zaphriphyllum disseptum* Echinoderms - undifferentiated *Pentremites godoni* crinoid cup - unidentified Foraminifers - endothyrid Pelecypods - undifferentiated *Deltopecten batesvillensis* Gastropods - undifferentiated	Bone fragments - undifferentiated **Fish:** *Soliorhyza* *Hiodus*	Spores	Williams and Bocock 1932; Laudon and Chronic 1947; Frebold 1955; Rutgers 1958; Langston 1959; Green 1962; Irish 1963; McGugan and Rapson-McGugan 1976; Pell, et al. 1992
Carboniferous	Rundle Group	Banff Formation M06, M30	Brachiopods: *Brachythris chuteauensis* *Cleiothyridina lata* *Composita athabascensis* *Composita immature* *Composita mumilis* *Platyrachella rutherfordi* *Rhynchotreta usheri* *Spinifer albertensis* *Spinifer cascadensis?* *Spinifer esplanadensis* *Spinifer greenockensis* *Spinifer marionensis*	Fish: *Helodus*	ND	Langston 1959; Green 1962

NOTES:
N/A = not applicable
ND = not detected
Taxa Within LAA
Taxa in close proximity to LAA
Taxa known regionally
Taxa known distant regions

o:\final\2012\1423\12-1423-0008\20121207_rpt_tdr_dft_gdr_vol4_app_c_heritage_v1\appendices\app d_summary of known palaeontological species by geological formation.doc.docx

APPENDIX E

Summary of Palaeontological Results

December 7, 2012
Report No. 12-1423-0008

APPENDIX F

Archaeological Site Descriptions

December 7, 2012
Report No. 12-1423-0008

APPENDIX G

Northwest Research Obsidian Laboratory Obsidian Sourcing Reports

December 7, 2012
Report No. 12-1423-0008

X-Ray Fluorescence Analysis of Artifact Obsidian from Sites Associated with the Peace River Site C Hydro Project: Heritage Program, British Columbia, Canada

Craig E. Skinner and Jennifer J. Thatcher
Northwest Research Obsidian Studies Laboratory

Thirty-five obsidian artifacts from sites AVW-T3 (N=17), HbRi-43 (N=12), and GDD-T6 (N=6), northeastern British Columbia, Canada, were submitted for energy dispersive X-ray fluorescence trace element provenance analysis. The samples were prepared and analyzed at the Northwest Research Obsidian Studies Laboratory under the accession number 2011-97.

Analytical Methods

X-Ray Fluorescence Analysis. Nondestructive trace element analysis of the samples were completed using a Spectrace 5000 energy dispersive X-ray fluorescence spectrometer. The system is equipped with a Si(Li) detector with a resolution of 155 eV FHWM for 5.9 keV X-rays (at 1000 counts per second) in an area 30 mm^2. Signals from the spectrometer are amplified and filtered by a time variant pulse processor and sent to a 100 MHZ Wilkinson type analog-to-digital converter. The X-ray tube employed is a Bremsstrahlung type, with a rhodium target, and 5 mil Be window. The tube is driven by a 50 kV 1 mA high voltage power supply, providing a voltage range of 4 to 50 kV. For the elements Zn, Rb, Sr, Y, Zr, Nb, and Pb that are reported in Table A-1, we analyzed the collection with a collimator installed and used a 45 kV tube voltage setting and 0.60 mA tube current setting.

The diagnostic trace element values used to characterize the samples are compared directly to those for known obsidian sources reported in the literature and with unpublished trace element data collected through analysis of geologic source samples (Northwest Research 2011a). Artifacts are correlated to a parent obsidian source (or geochemical source group) if diagnostic trace element values fall within about two standard deviations of the analytical uncertainty of the known upper and lower limits of chemical variability recorded for the source. Occasionally, visual attributes are used to corroborate the source assignments although sources are never assigned solely on the basis of megascopic characteristics.

Additional details about specific analytical methods and procedures used for the analysis of the elements reported in Table A-1 are available at the Northwest Research Obsidian Studies Laboratory World Wide Web site at *www.obsidianlab.com* (Northwest Research 2011a).

Results of Analysis

X-Ray Fluorescence Analysis. Four geochemical sources were identified among the 35 artifacts that were characterized by X-ray fluorescence analysis. The trace element composition of one of the artifacts indicates that it is not obsidian. The locations of the sites and the obsidian source area are shown in Figure 1. Analytical results are presented in Table A-1 in the Appendix and are summarized in Table 1 and Figure 2.

Table 1. Summary of results of trace element studies of artifacts from the project sites.

OBSIDIAN SOURCES	PROJECT SITES			TOTAL
	AVW-T3	HbRi-43	GDD-T6	
Anahim	–	9	–	9
Ilgachuz	–	–	6	6
Mt. Edziza Flow 3	14	3	–	17
Not Obsidian	1	–	–	1
Unknown Obsidian A	2	–	–	2
TOTAL	**17**	**12**	**6**	**35**

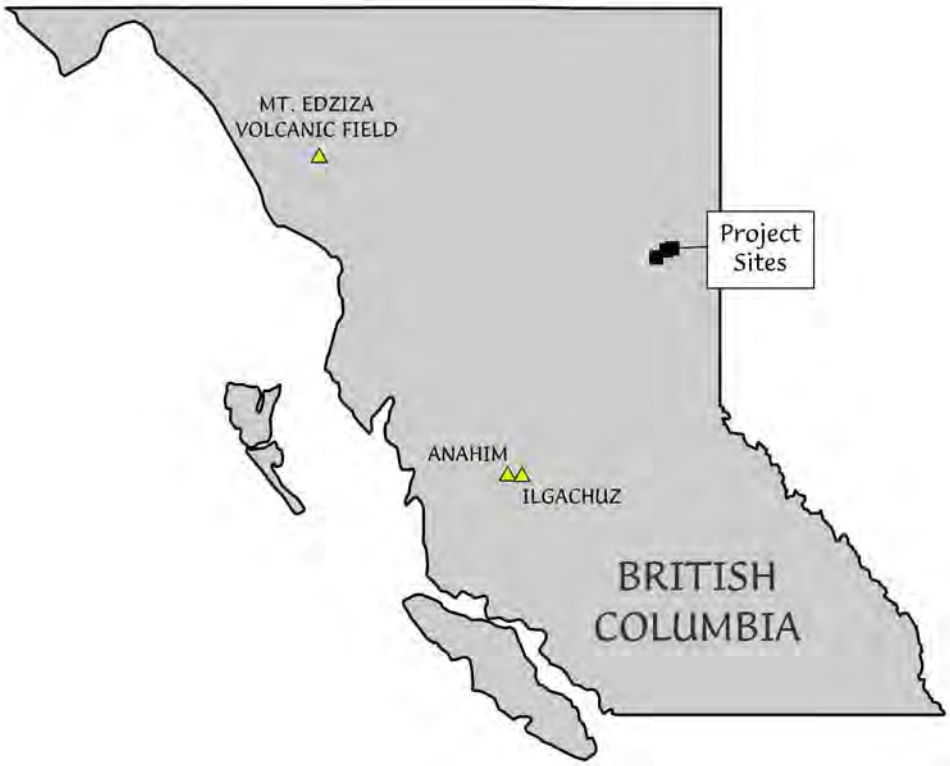

Figure 1. Locations of the project area and the sources of the obsidian artifacts.

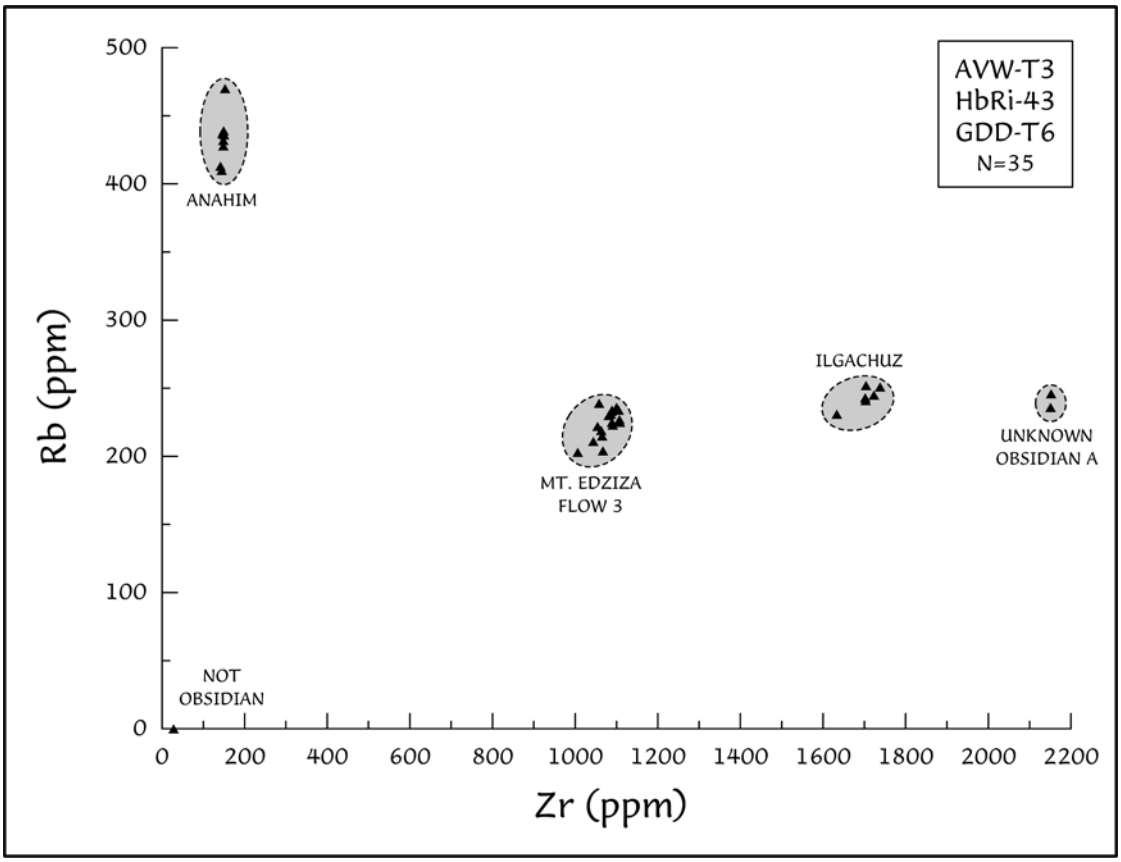

Figure 2. Scatterplot of zirconium (Zr) versus rubidium (Rb) for all analyzed artifacts.

At least 10 different geochemical sources (flows) of obsidian from the Mt. Edziza Volcanic Field have been proposed by Godfrey-Smith (1985) and our modest collection of analyzed comparative samples from this area includes only a subset of these. However, three artifacts that had been previously analyzed by the Simon Fraser University XRF Laboratory and assigned to the Mt. Edziza 2 and Mt. Edziza 3 flows have been reanalyzed by our laboratory in an effort to supplement our comparative data for the Mt. Edziza obsidian sources. Seventeen of the artifacts analyzed in the current investigation were firmly correlated with the previously identified Mt. Edziza Flow 3 source.

The trace element composition of two artifacts from AVW-T3 indicates that they belong to a single unknown geochemical chemical source. The co-occurrence at the site of a large proportion of obsidian from Mt. Edziza suggests that this unknown source may also be found in the Mt. Edziza Volcanic Field.

Further studies about the geologic setting and prehistoric use of the Mt. Edziza sources may be found in Aumento and Souther (1973), Bennett and D'Auria (1974), Carlson (1994), D'Auria et al. (1992), Fladmark (1984, 1985), Godfrey-Smith (1985), Huntley and Bailey (1978), Nelson et al. (1975), Souther (1992), and Souther et al. (1984). Additional details concerning the Anahim and Ilgachuz sources are available in Bennett and D'Auria (1974), Carlson (1994), D'Auria et al. (1992), Hayden (1991), Huntley and Bailey (1978), Nelson and Will (1976), Nelson et al. (1975), and Reimer (2000).

Additional information about the sources may also be found at *www.sourcecatalog.com* (Northwest Research 2011b).

References Cited

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Appendix

Results of X-Ray Fluorescence Analysis

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Sites Associated with the Peace River Site C Hydro Project: Heritage Program, British Columbia

Site	Specimen No.	Catalog No.	Trace Element Concentrations											Ratios		Geochemical Source
			Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe^2O^{3T}	Fe:Mn	Fe:Ti	
AVW-T3	1	1	237	22	204	7	119	1067	132	NM	NM	NM	NM	54.7	94.0	Mt. Edziza Flow 3 *
			± 17	6	5	9	4	8	2	NM	NM	NM	NM			
AVW-T3	2	2	262	41	230	7	124	1081	141	NM	NM	NM	NM	56.4	92.5	Mt. Edziza Flow 3 *
			± 17	6	5	9	4	8	2	NM	NM	NM	NM			
AVW-T3	3	3	260	35	225	7	132	1108	144	NM	NM	NM	NM	50.8	95.2	Mt. Edziza Flow 3 *
			± 17	6	5	9	4	8	2	NM	NM	NM	NM			
AVW-T3	4	4	292	30	231	8	123	1086	142	NM	NM	NM	NM	57.7	101.0	Mt. Edziza Flow 3 *
			± 18	6	5	9	4	8	2	NM	NM	NM	NM			
AVW-T3	5	5	321	49	234	8	130	1105	132	NM	NM	NM	NM	53.1	86.6	Mt. Edziza Flow 3 *
			± 18	6	5	9	4	8	3	NM	NM	NM	NM			
AVW-T3	6	6	247	28	225	6	129	1089	137	NM	NM	NM	NM	51.4	69.0	Mt. Edziza Flow 3 *
			± 17	6	5	10	4	8	2	NM	NM	NM	NM			
AVW-T3	7	7	292	40	234	10	130	1089	140	NM	NM	NM	NM	53.3	66.2	Mt. Edziza Flow 3 *
			± 19	7	5	9	4	8	3	NM	NM	NM	NM			
AVW-T3	8	8	286	36	239	7	120	1058	126	NM	NM	NM	NM	54.9	71.6	Mt. Edziza Flow 3 *
			± 19	6	5	9	4	8	2	NM	NM	NM	NM			
AVW-T3	9	9	286	34	223	8	123	1091	138	NM	NM	NM	NM	54.7	64.3	Mt. Edziza Flow 3 *
			± 18	6	5	9	4	8	2	NM	NM	NM	NM			
AVW-T3	10	10	301	36	222	11	127	1054	122	NM	NM	NM	NM	53.8	61.5	Mt. Edziza Flow 3 *
			± 20	8	5	9	4	9	3	NM	NM	NM	NM			
AVW-T3	11	11	256	41	215	7	125	1065	138	NM	NM	NM	NM	53.2	64.7	Mt. Edziza Flow 3 *
			± 17	5	5	9	4	8	2	NM	NM	NM	NM			
AVW-T3	12	12	264	40	227	7	131	1107	139	NM	NM	NM	NM	58.0	91.2	Mt. Edziza Flow 3 *
			± 17	6	5	9	4	8	2	NM	NM	NM	NM			
AVW-T3	13	13	248	37	236	8	127	1100	144	NM	NM	NM	NM	55.5	93.5	Mt. Edziza Flow 3 *
			± 17	6	5	9	4	8	2	NM	NM	NM	NM			
AVW-T3	14	14	262	43	233	7	127	1088	140	NM	NM	NM	NM	56.4	94.1	Mt. Edziza Flow 3 *
			± 17	6	5	9	4	8	2	NM	NM	NM	NM			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured; * = Small sample; FGV = Fine-grained volcanic specimen.

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Sites Associated with the Peace River Site C Hydro Project: Heritage Program, British Columbia

Site	Specimen No.	Catalog No.	Trace Element Concentrations											Ratios		Geochemical Source
			Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe^2O^{3T}	Fe:Mn	Fe:Ti	
AVW-T3	15	15	21	3	0	9	ND	28	2	NM	NM	NM	0.25	20.4	15.8	Not Obsidian
			± 17	6	4	9	ND	7	3	NM	NM	NM	NM			
AVW-T3	16	16	552	53	236	15	251	2151	250	NM	NM	NM	NM	58.8	235.9	Unknown Obsidian A *
			± 20	6	5	9	4	10	3	NM	NM	NM	NM			
AVW-T3	17	17	581	45	246	8	255	2152	251	NM	NM	NM	NM	61.2	225.4	Unknown Obsidian A *
			± 20	6	5	9	4	10	3	NM	NM	NM	NM			
HbRi-43	18	18	203	26	203	9	114	1006	133	NM	NM	NM	NM	54.8	61.1	Mt. Edziza Flow 3 *
			± 17	6	5	9	4	8	2	NM	NM	NM	NM			
HbRi-43	19	19	245	40	219	7	120	1063	132	NM	NM	NM	NM	64.2	96.9	Mt. Edziza Flow 3 *
			± 17	6	5	9	4	8	2	NM	NM	NM	NM			
HbRi-43	20	20	223	48	439	16	121	149	141	NM	NM	NM	NM	22.7	132.9	Anahim *
			± 16	6	5	9	4	7	2	NM	NM	NM	NM			
HbRi-43	21	21	215	21	211	ND	120	1044	131	NM	NM	NM	NM	58.7	70.4	Mt. Edziza Flow 3 *
			± 17	6	5	ND	4	8	2	NM	NM	NM	NM			
HbRi-43	22	22	192	49	428	14	113	148	142	NM	NM	NM	NM	22.4	114.1	Anahim *
			± 16	5	5	9	4	7	2	NM	NM	NM	NM			
HbRi-43	23	23	245	54	470	16	126	152	142	NM	NM	NM	NM	21.1	140.0	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
HbRi-43	24	24	229	54	436	17	115	150	137	NM	NM	NM	NM	22.4	49.3	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
GDD-T6	25	25	395	30	251	7	156	1738	243	NM	NM	NM	NM	50.7	107.6	Ilgachuz *
			± 18	6	5	9	4	9	3	NM	NM	NM	NM			
GDD-T6	26	26	325	29	243	8	145	1702	247	NM	NM	NM	NM	49.2	114.6	Ilgachuz *
			± 19	6	5	9	4	9	3	NM	NM	NM	NM			
GDD-T6	27	27	320	25	231	10	144	1633	234	NM	NM	NM	NM	51.0	88.7	Ilgachuz *
			± 20	7	5	9	4	10	3	NM	NM	NM	NM			
GDD-T6	28	28	335	39	252	7	150	1704	239	NM	NM	NM	NM	49.2	97.2	Ilgachuz *
			± 19	6	5	9	4	9	3	NM	NM	NM	NM			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured; * = Small sample; FGV = Fine-grained volcanic specimen.

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Sites Associated with the Peace River Site C Hydro Project: Heritage Program, British Columbia

Site	Specimen No.	Catalog No.	Trace Element Concentrations											Ratios		Geochemical Source
			Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe^2O^{3T}	Fe:Mn	Fe:Ti	
GDD-T6	29	29	344	36	241	7	149	1703	241	NM	NM	NM	NM	48.9	110.7	Ilgachuz *
			± 18	6	5	9	4	9	3	NM	NM	NM	NM			
GDD-T6	30	30	381	31	245	ND	149	1723	248	NM	NM	NM	NM	49.6	107.5	Ilgachuz *
			± 18	6	5	ND	4	9	3	NM	NM	NM	NM			
HbRi-43	31	31	220	47	410	14	119	144	137	NM	NM	NM	NM	12.7	122.1	Anahim
			± 16	6	5	9	4	7	2	NM	NM	NM	NM			
HbRi-43	32	32	240	44	437	15	113	146	141	NM	NM	NM	NM	15.3	126.6	Anahim
			± 16	5	5	9	4	7	2	NM	NM	NM	NM			
HbRi-43	33	33	210	50	413	13	113	141	136	NM	NM	NM	NM	20.7	64.9	Anahim
			± 16	5	5	9	4	7	2	NM	NM	NM	NM			
HbRi-43	34	34	204	57	432	13	117	148	143	NM	NM	NM	NM	20.1	40.9	Anahim
			± 16	5	5	9	4	7	2	NM	NM	NM	NM			
HbRi-43	35	35	211	40	413	15	110	141	134	NM	NM	NM	NM	18.6	33.4	Anahim
			± 16	5	5	9	4	7	2	NM	NM	NM	NM			
NA	RGM-1	RGM-1	27	15	155	100	25	220	7	NM	NM	NM	NM	45.8	37.2	RGM-1 Reference Standard
			± 17	6	4	9	4	7	2	NM	NM	NM	NM			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured; * = Small sample; FGV = Fine-grained volcanic specimen.

X-Ray Fluorescence Analysis of Artifact Obsidian from Sites Associated with the Site C Clean Energy Project – Heritage Impact Assessment Program Year 3, British Columbia, Canada

Craig E. Skinner and Jennifer J. Thatcher
Northwest Research Obsidian Studies Laboratory

Eleven obsidian artifacts from four sites associated with the Site C Clean Energy Project - Heritage Impact Assessment Program Year 3, northeastern British Columbia, Canada, were submitted for energy dispersive X-ray fluorescence trace element provenance analysis. The samples were prepared and analyzed at the Northwest Research Obsidian Studies Laboratory under the accession number 2012-90.

Analytical Methods

X-Ray Fluorescence Analysis. Nondestructive trace element analysis of the samples were completed using a Spectrace 5000 energy dispersive X-ray fluorescence spectrometer. The system is equipped with a Si(Li) detector with a resolution of 155 eV FHWM for 5.9 keV X-rays (at 1000 counts per second) in an area 30 mm^2. Signals from the spectrometer are amplified and filtered by a time variant pulse processor and sent to a 100 MHZ Wilkinson type analog-to-digital converter. The X-ray tube employed is a Bremsstrahlung type, with a rhodium target, and 5 mil Be window. The tube is driven by a 50 kV 1 mA high voltage power supply, providing a voltage range of 4 to 50 kV. For the elements Zn, Rb, Sr, Y, Zr, Nb, and Pb that are reported in Table A-1, we analyzed the collection with a collimator installed and used a 45 kV tube voltage setting and 0.60 mA tube current setting.

The diagnostic trace element values used to characterize the samples are compared directly to those for known obsidian sources reported in the literature and with unpublished trace element data collected through analysis of geologic source samples (Northwest Research 2012a). Artifacts are correlated to a parent obsidian source (or geochemical source group) if diagnostic trace element values fall within about two standard deviations of the analytical uncertainty of the known upper and lower limits of chemical variability recorded for the source. Occasionally, visual attributes are used to corroborate the source assignments although sources are never assigned solely on the basis of megascopic characteristics.

Additional details about specific analytical methods and procedures used for the analysis of the elements reported in Table A-1 are available at the Northwest Research Obsidian Studies Laboratory World Wide Web site at *www.obsidianlab.com* (Northwest Research 2012a).

Results of Analysis

X-Ray Fluorescence Analysis. Three geochemical sources were identified among the 11 artifacts that were characterized by X-ray fluorescence analysis. The locations of the project sites and the obsidian source areas are shown in Figure 1. Analytical results are presented in Table A-1 in the Appendix and are summarized in Table 1 and Figure 2.

Table 1. Summary of results of trace element studies of artifacts from the project sites.

OBSIDIAN SOURCES	PROJECT SITES				TOTAL
	ASLP-R-2	AMO-2012-T1	HbRg-11	GHC-12-02	
Anahim	1	3	–	4	8
Mt. Edziza Flow 2	–	–	–	2	2
Mt. Edziza Flow 3	–	–	1	–	1
TOTAL	**1**	**3**	**1**	**6**	**11**

Figure 1. Locations of the project area and the sources of the obsidian artifacts.

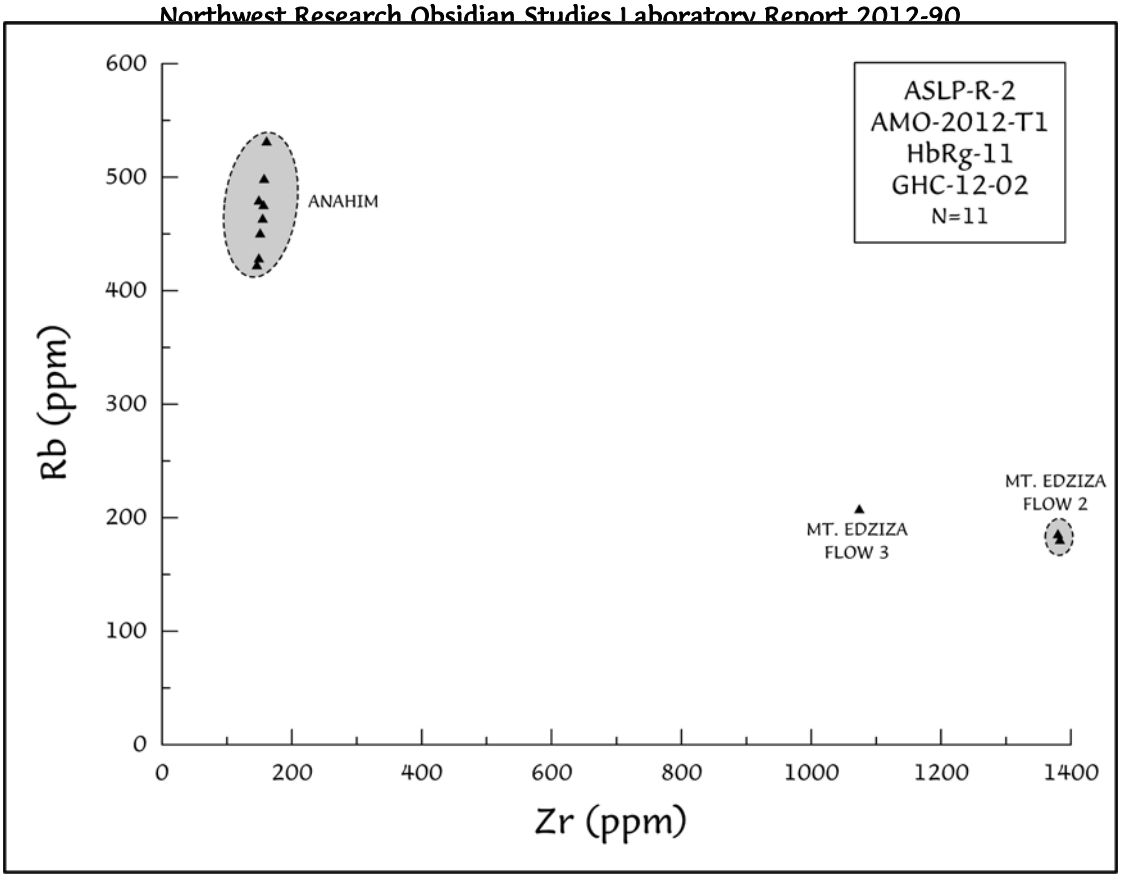

Figure 2. Scatterplot of zirconium (Zr) versus rubidium (Rb) for all analyzed artifacts.

At least 10 different geochemical sources (flows) of obsidian from the Mt. Edziza Volcanic Field have been proposed by Godfrey-Smith (1985) and our modest collection of analyzed comparative samples from this area includes only a subset of these. However, three artifacts that had been previously analyzed by the Simon Fraser University XRF Laboratory and assigned to the Mt. Edziza 2 and Mt. Edziza 3 flows have been reanalyzed by our laboratory in an effort to supplement our comparative data for the Mt. Edziza obsidian sources. Three of the artifacts analyzed in the current investigation were firmly correlated with the previously identified Mt. Edziza sources.

Further studies about the geologic setting and prehistoric use of the Mt. Edziza sources may be found in Aumento and Souther (1973), Bennett and D'Auria (1974), Carlson (1994), D'Auria et al. (1992), Fladmark (1984, 1985), Godfrey-Smith (1985), Huntley and Bailey (1978), Nelson et al. (1975), Souther (1992), and Souther et al. (1984). Additional details concerning the Anahim sources are available in Bennett and D'Auria (1974), Carlson (1994), D'Auria et al. (1992), Hayden and Ryder (1991), Huntley and Bailey (1978), Nelson and Will (1976), Nelson et al. (1975), and Reimer (2000).

Additional information about the sources may also be found at *www.sourcecatalog.com* (Northwest Research 2012b).

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Appendix

Results of X-Ray Fluorescence Analysis

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Sites Associated with the Site C Clean Energy Project, British Columbia, Canada

Site	Specimen No.	Catalog No.	Trace Element Concentrations											Ratios		Geochemical Source
			Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe^2O^{3T}	Fe:Mn	Fe:Ti	
ASLP-R-2	1	42823	241	58	476	16	118	156	148	NM	NM	NM	NM	NM	NM	Anahim *
			± 18	7	6	9	4	7	2	NM	NM	NM	NM			
AMO-2012-T1	2	45025	240	39	451	16	116	151	145	NM	NM	NM	NM	NM	NM	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
AMO-2012-T1	3	45043	258	55	499	15	132	157	152	NM	NM	NM	NM	NM	NM	Anahim *
			± 18	6	6	9	4	7	2	NM	NM	NM	NM			
AMO-2012-T1	4	54107	250	51	464	14	121	155	149	NM	NM	NM	NM	NM	NM	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
HbRg-11	5	31719	254	25	208	8	119	1074	136	NM	NM	NM	NM	NM	NM	Mt. Edziza Flow 3 *
			± 17	6	5	9	4	8	2	NM	NM	NM	NM			
GHC-12-02	6	40591A	219	52	423	15	116	146	137	NM	NM	NM	NM	NM	NM	Anahim *
			± 16	6	5	9	4	7	2	NM	NM	NM	NM			
GHC-12-02	7	40591B	411	25	186	10	135	1380	200	NM	NM	NM	NM	NM	NM	Mt. Edziza Flow 2 *
			± 19	6	5	9	4	9	3	NM	NM	NM	NM			
GHC-12-02	8	40591C	256	41	480	19	116	149	143	NM	NM	NM	NM	NM	NM	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
GHC-12-02	9	40591D	393	20	181	5	139	1383	201	NM	NM	NM	NM	NM	NM	Mt. Edziza Flow 2 *
			± 20	7	5	9	4	9	3	NM	NM	NM	NM			
GHC-12-02	10	40591E	339	57	532	15	123	161	157	NM	NM	NM	NM	NM	NM	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
GHC-12-02	11	40591F	218	55	429	17	117	149	140	NM	NM	NM	NM	NM	NM	Anahim
			± 16	6	5	9	4	7	2	NM	NM	NM	NM			
NA	RGM-1	RGM-1	34	29	148	97	27	214	7	NM	NM	NM	NM	NM	NM	RGM-1 Reference Standard
			± 17	5	4	9	4	7	2	NM	NM	NM	NM			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured; * = Small sample; FGV = Fine-grained volcanic specimen.

X-Ray Fluorescence Analysis of Artifact Obsidian from Sites Associated with the Site C Clean Energy Project – Heritage Impact Assessment Program Year 3, British Columbia, Canada

Craig E. Skinner and Jennifer J. Thatcher
Northwest Research Obsidian Studies Laboratory

Twenty obsidian artifacts from three sites associated with the Site C Clean Energy Project - Heritage Impact Assessment Program Year 3, northeastern British Columbia, Canada, were submitted for energy dispersive X-ray fluorescence trace element provenance analysis. The samples were prepared and analyzed at the Northwest Research Obsidian Studies Laboratory under the accession number 2012-105.

Analytical Methods

X-Ray Fluorescence Analysis. Nondestructive trace element analysis of the samples were completed using a Spectrace 5000 energy dispersive X-ray fluorescence spectrometer. The system is equipped with a Si(Li) detector with a resolution of 155 eV FHWM for 5.9 keV X-rays (at 1000 counts per second) in an area 30 mm^2. Signals from the spectrometer are amplified and filtered by a time variant pulse processor and sent to a 100 MHZ Wilkinson type analog-to-digital converter. The X-ray tube employed is a Bremsstrahlung type, with a rhodium target, and 5 mil Be window. The tube is driven by a 50 kV 1 mA high voltage power supply, providing a voltage range of 4 to 50 kV. For the elements Zn, Rb, Sr, Y, Zr, Nb, and Pb that are reported in Table A-1, we analyzed the collection with a collimator installed and used a 45 kV tube voltage setting and 0.60 mA tube current setting.

The diagnostic trace element values used to characterize the samples are compared directly to those for known obsidian sources reported in the literature and with unpublished trace element data collected through analysis of geologic source samples (Northwest Research 2012a). Artifacts are correlated to a parent obsidian source (or geochemical source group) if diagnostic trace element values fall within about two standard deviations of the analytical uncertainty of the known upper and lower limits of chemical variability recorded for the source. Occasionally, visual attributes are used to corroborate the source assignments although sources are never assigned solely on the basis of megascopic characteristics.

Additional details about specific analytical methods and procedures used for the analysis of the elements reported in Table A-1 are available at the Northwest Research Obsidian Studies Laboratory World Wide Web site at *www.obsidianlab.com* (Northwest Research 2012a).

Results of Analysis

X-Ray Fluorescence Analysis. Three geochemical sources were identified among the 20 artifacts that were characterized by X-ray fluorescence analysis. The locations of the project sites and the obsidian source areas are shown in Figure 1. Analytical results are presented in Table A-1 in the Appendix and are summarized in Table 1 and Figure 2.

Table 1. Summary of results of trace element studies of artifacts from the project sites.

PROJECT SITES	OBSIDIAN SOURCES			TOTAL
	ANAHIM	BEAR GULCH	MT. EDZIZA	
GDO-12-T3	15	3	–	18
ARD-12-T6	1	–	–	1
HaRk-23	–	–	1	1
TOTAL	**16**	**3**	**1**	**20**

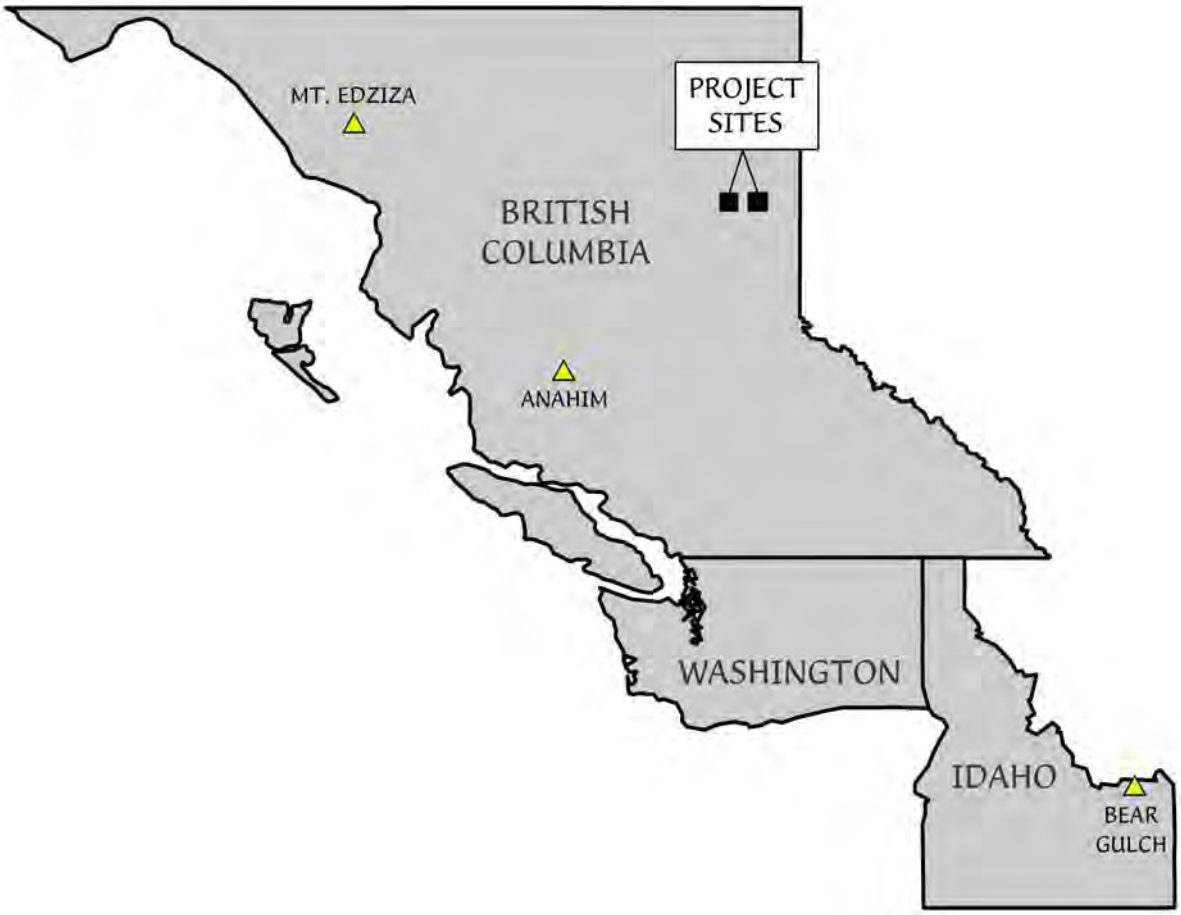

Figure 1. Locations of the project area and the sources of the obsidian artifacts.

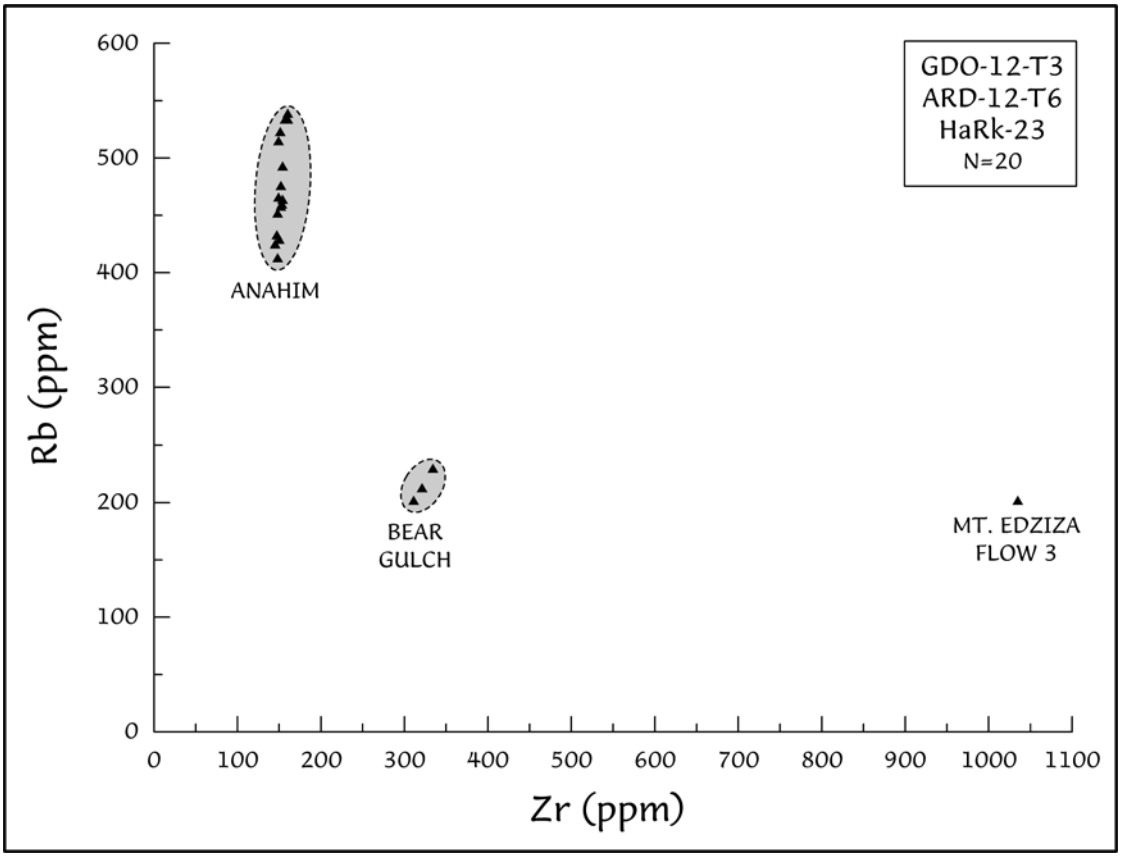

Figure 2. Scatterplot of zirconium (Zr) versus rubidium (Rb) for all analyzed artifacts.

Previous trace element provenance studies in the project area by Skinner and Thatcher (2011, 2012) have identified obsidian from several different British Columbia obsidian sources (Anahim, Ilgachuz, and Mt. Edziza). The results of the current investigation, however, are the first that have found evidence of volcanic glass from United States obsidian sources.

Additional information about the locations, geologic setting, and archaeological significance of the two obsidian sources may also be found at *www.sourcecatalog.com* (Northwest Research 2012b).

References Cited

Northwest Research Obsidian Studies Laboratory
2012a Northwest Research Obsidian Studies Laboratory World Wide Web Site (www.obsidianlab.com).

2012b Northwest Research United States and Canada Obsidian Source Catalog (www.sourcecatalog.com).

Skinner, Craig E. and Jennifer J. Thatcher
2011 *X-Ray Fluorescence Analysis of Artifact Obsidian from Sites Associated with the Peace River Site C Hydro Project: Heritage Program, British Columbia, Canada.* Report 2011-97 prepared for AMEC Environment & Infrastructure, Burnaby, British Columbia, Canada, by Northwest Research Obsidian Studies Laboratory, Corvallis, Oregon.

Northwest Research Obsidian Studies Laboratory Report 2012-105

2012 *X-Ray Fluorescence Analysis of Artifact Obsidian from Sites Associated with the Site C Clean Energy Project - Heritage Impact Assessment Program Year 3, British Columbia, Canada*. Report 2012-90 prepared for AMEC Environmental and Infrastructure, Burnaby, British Columbia, Canada, by Northwest Research Obsidian Studies Laboratory, Corvallis, Oregon.

Appendix

Results of X-Ray Fluorescence Analysis

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Sites Associated with the Site C Clean Energy Project, British Columbia, Canada

Site	Specimen No.	Catalog No.	Trace Element Concentrations											Ratios		Geochemical Source
			Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe^2O^{3T}	Fe:Mn	Fe:Ti	
GDO-12-T3	1	8 (a)	79	28	213	49	51	321	66	NM	NM	NM	NM	NM	NM	Bear Gulch *
			± 17	7	5	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	2	8 (b)	91	35	230	60	53	334	56	NM	NM	NM	NM	NM	NM	Bear Gulch? *
			± 18	7	5	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	3	2	62	30	202	49	47	311	61	NM	NM	NM	NM	NM	NM	Bear Gulch *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	4	11	193	53	429	10	117	150	141	NM	NM	NM	NM	NM	NM	Anahim
			± 16	5	5	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	5	15 (a)	198	41	413	15	118	148	140	NM	NM	NM	NM	NM	NM	Anahim *
			± 16	6	5	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	6	15 (b)	225	59	493	14	120	154	144	NM	NM	NM	NM	NM	NM	Anahim *
			± 18	6	6	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	7	16	248	41	466	16	120	149	147	NM	NM	NM	NM	NM	NM	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	8	17	230	56	458	15	121	152	151	NM	NM	NM	NM	NM	NM	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	9	18	319	65	534	13	124	160	147	NM	NM	NM	NM	NM	NM	Anahim *
			± 18	6	6	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	10	19	251	51	464	12	118	154	150	NM	NM	NM	NM	NM	NM	Anahim *
			± 16	6	5	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	11	22 (a)	219	48	425	15	118	145	142	NM	NM	NM	NM	NM	NM	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	12	22 (b)	253	69	523	18	127	151	147	NM	NM	NM	NM	NM	NM	Anahim *
			± 19	7	6	9	4	7	3	NM	NM	NM	NM			
GDO-12-T3	13	25	261	69	476	15	121	152	146	NM	NM	NM	NM	NM	NM	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	14	26	236	46	460	14	120	153	151	NM	NM	NM	NM	NM	NM	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured; * = Small sample; FGV = Fine-grained volcanic specimen.

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Sites Associated with the Site C Clean Energy Project, British Columbia, Canada

Site	Specimen No.	Catalog No.	Trace Element Concentrations											Ratios		Geochemical Source
			Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe^2O^{3T}	Fe:Mn	Fe:Ti	
GDO-12-T3	15	29	213	50	433	12	117	147	139	NM	NM	NM	NM	NM	NM	Anahim
			± 16	5	5	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	16	30a	352	70	534	14	121	157	142	NM	NM	NM	NM	NM	NM	Anahim *
			± 18	6	6	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	17	30c (a)	308	75	539	17	130	160	151	NM	NM	NM	NM	NM	NM	Anahim *
			± 18	6	6	9	4	7	2	NM	NM	NM	NM			
GDO-12-T3	18	30c (b)	225	56	452	13	123	148	142	NM	NM	NM	NM	NM	NM	Anahim *
			± 17	6	5	9	4	7	2	NM	NM	NM	NM			
ARD-12-T6	19	1	264	35	515	13	128	149	142	NM	NM	NM	NM	NM	NM	Anahim *
			± 19	7	6	9	4	7	3	NM	NM	NM	NM			
HaRk-23	20	1	246	35	202	8	120	1035	132	NM	NM	NM	NM	NM	NM	Mt. Edziza Flow 3
			± 17	6	5	9	4	8	2	NM	NM	NM	NM			
NA	RGM-1	RGM-1	14	26	140	93	24	215	9	NM	NM	NM	NM	NM	NM	RGM-1 Reference Standard
			± 24	5	4	9	4	7	2	NM	NM	NM	NM			

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured; * = Small sample; FGV = Fine-grained volcanic specimen.

APPENDIX H

Beta Analytic Inc. Radiocarbon Data Reports

Beta Analytic Inc.
4985 SW 74 Court
Miami, Florida 33155 USA
Tel: 305 667 5167
Fax: 305 663 0964
Beta@radiocarbon.com
www.radiocarbon.com

Consistent Accuracy . . .
. . . Delivered On-time

Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

October 10, 2011

Dr. Nova Pierson
AMEC Environment and Infrastructure
600-4445 Lougheed Highway
Burnaby, BC V5C 0E4
Canada

RE: Radiocarbon Dating Results For Samples GDD6EU1-55, GDD6EU2-58, AJKT46-2025, ARDT7-28329, GCT16437, GCDT3EU1-45, GCDT329035, GDD6EU2-5055, GKCT1-29097, MKBHBRI10108

Dear Dr. Pierson:

Enclosed are the radiocarbon dating results for ten samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. The report sheet also contains the method used, material type, and applied pretreatments and, where applicable, the two-sigma calendar calibration range.

As always, this report has been both mailed and sent electronically. All results (excluding some inappropriate material types) which are less than about 20,000 years BP and more than about ~250 BP include this calendar calibration page (also digitally available in Windows metafile (wmf) format upon request). The calibrations are calculated using the newest (2004) calibration database with references quoted on the bottom of each page. Multiple probability ranges may appear in some cases, due to short-term variations in the atmospheric 14C contents at certain time periods. Examining the calibration graphs will help you understand this phenomenon. Don't hesitate to contact us if you have questions about calibration.

We analyzed these samples on a sole priority basis. No students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

Information pages are also enclosed with the mailed copy of this report. If you have any specific questions about the analyses, please do not hesitate to contact us.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Nova Pierson — Report Date: 10/10/2011

AMEC Environment and Infrastructure — Material Received: 9/30/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 306771	1770 +/- 40 BP	-24.4 o/oo	1780 +/- 40 BP
SAMPLE : GDD6EU1-55			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 130 to 350 (Cal BP 1820 to 1600)			
Beta - 306772	1680 +/- 40 BP	-23.9 o/oo	1700 +/- 40 BP
SAMPLE : GDD6EU2-58			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 240 to 420 (Cal BP 1710 to 1530)			
Beta - 306773	2810 +/- 40 BP	-21.1 o/oo	2870 +/- 40 BP
SAMPLE : AJKT46-2025			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali			
2 SIGMA CALIBRATION : Cal BC 1190 to 1140 (Cal BP 3140 to 3090) AND Cal BC 1140 to 920 (Cal BP 3090 to 2870)			
Beta - 306774	1270 +/- 40 BP	-21.5 o/oo	1330 +/- 40 BP
SAMPLE : ARDT7-28329			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali			
2 SIGMA CALIBRATION : Cal AD 640 to 770 (Cal BP 1300 to 1180)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Nova Pierson

Report Date: 10/10/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 306775	4340 +/- 40 BP	-20.7 o/oo	4410 +/- 40 BP
SAMPLE : GCT16437			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali			
2 SIGMA CALIBRATION : Cal BC 3320 to 3230 (Cal BP 5270 to 5180) AND Cal BC 3110 to 2910 (Cal BP 5060 to 4860)			
Beta - 306776	2760 +/- 40 BP	-21.2 o/oo	2820 +/- 40 BP
SAMPLE : GCDT3EU1-45			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali			
2 SIGMA CALIBRATION : Cal BC 1080 to 900 (Cal BP 3030 to 2850)			
Beta - 306777	250 +/- 40 BP	-20.9 o/oo	320 +/- 40 BP
SAMPLE : GCDT329035			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali			
2 SIGMA CALIBRATION : Cal AD 1460 to 1660 (Cal BP 490 to 290)			
Beta - 306778	1640 +/- 40 BP	-20.7 o/oo	1710 +/- 40 BP
SAMPLE : GDD6EU2-5055			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali			
2 SIGMA CALIBRATION : Cal AD 240 to 420 (Cal BP 1710 to 1530)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

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beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Nova Pierson

Report Date: 10/10/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 306779	2040 +/- 40 BP	-25.1 o/oo	2040 +/- 40 BP
SAMPLE : GKCT1-29097			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (cremated bone carbonate): bone carbonate extraction			
2 SIGMA CALIBRATION : Cal BC 170 to Cal AD 50 (Cal BP 2120 to 1900)			
Beta - 306780	110 +/- 40 BP	-19.3 o/oo	200 +/- 40 BP
SAMPLE : MKBHBRI10108			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali			
2 SIGMA CALIBRATION : Cal AD 1640 to 1700 (Cal BP 310 to 260) AND Cal AD 1720 to 1820 (Cal BP 220 to 140) Cal AD 1920 to 1950 (Cal BP 30 to 0)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

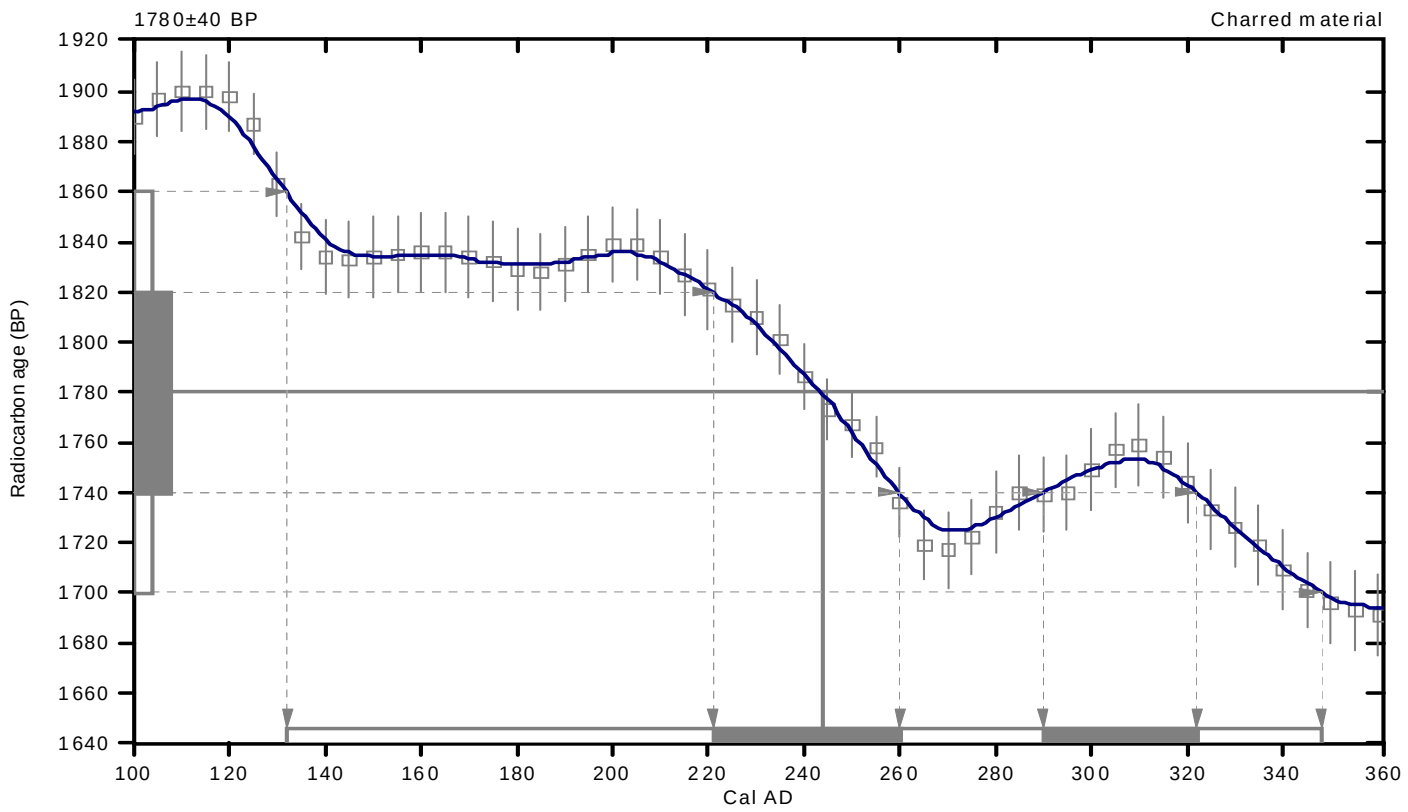
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.4:lab. mult=1)

Laboratory number:	**Beta-306771**
Conventional radiocarbon age:	**1780±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 130 to 350 (Cal BP 1820 to 1600)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 240 (Cal BP 1710)
1 Sigma calibrated results: (68% probability)	Cal AD 220 to 260 (Cal BP 1730 to 1690) and Cal AD 290 to 320 (Cal BP 1660 to 1630)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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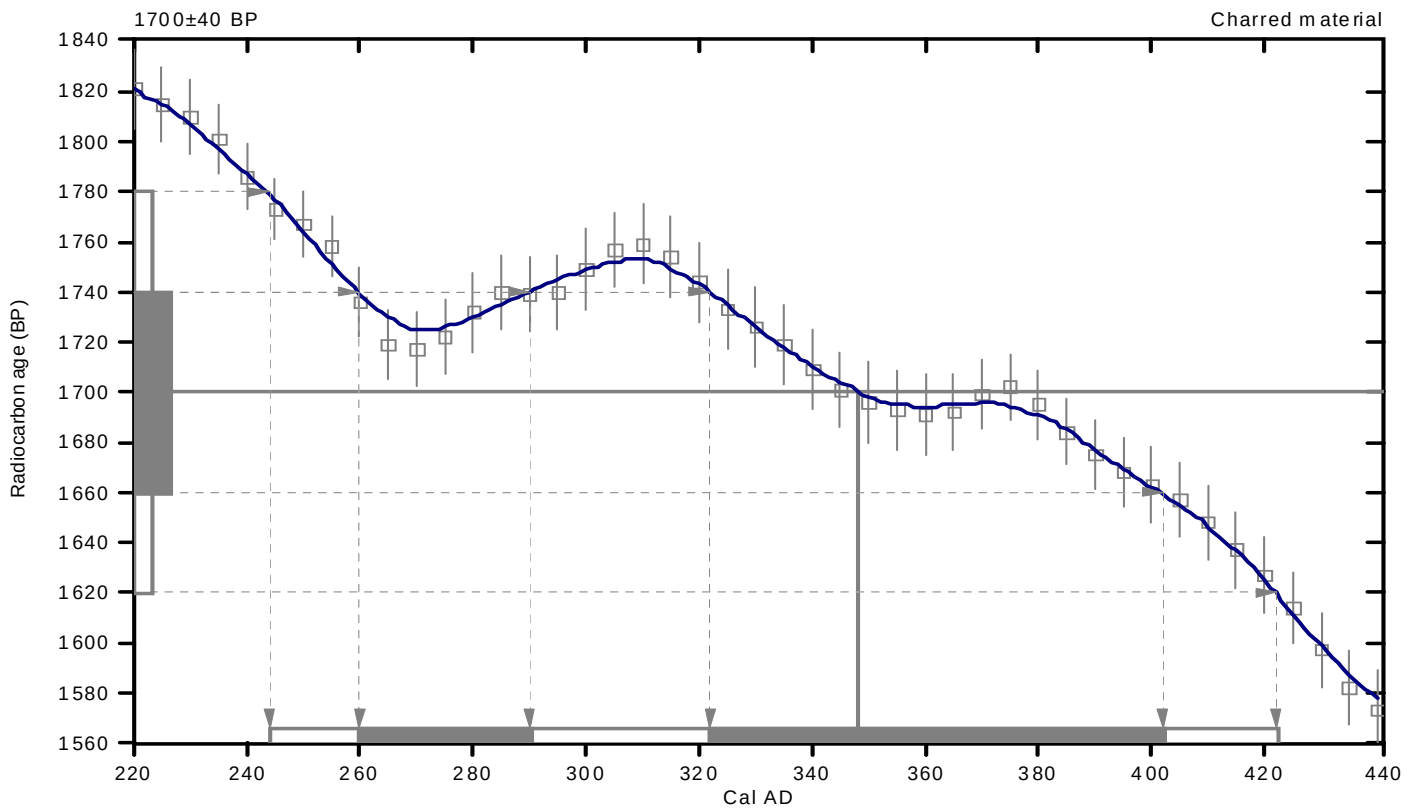
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.9:lab. mult=1)

Laboratory number:	**Beta-306772**
Conventional radiocarbon age:	**1700±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 240 to 420 (Cal BP 1710 to 1530)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 350 (Cal BP 1600)
1 Sigma calibrated results: (68% probability)	Cal AD 260 to 290 (Cal BP 1690 to 1660) and Cal AD 320 to 400 (Cal BP 1630 to 1550)



References:

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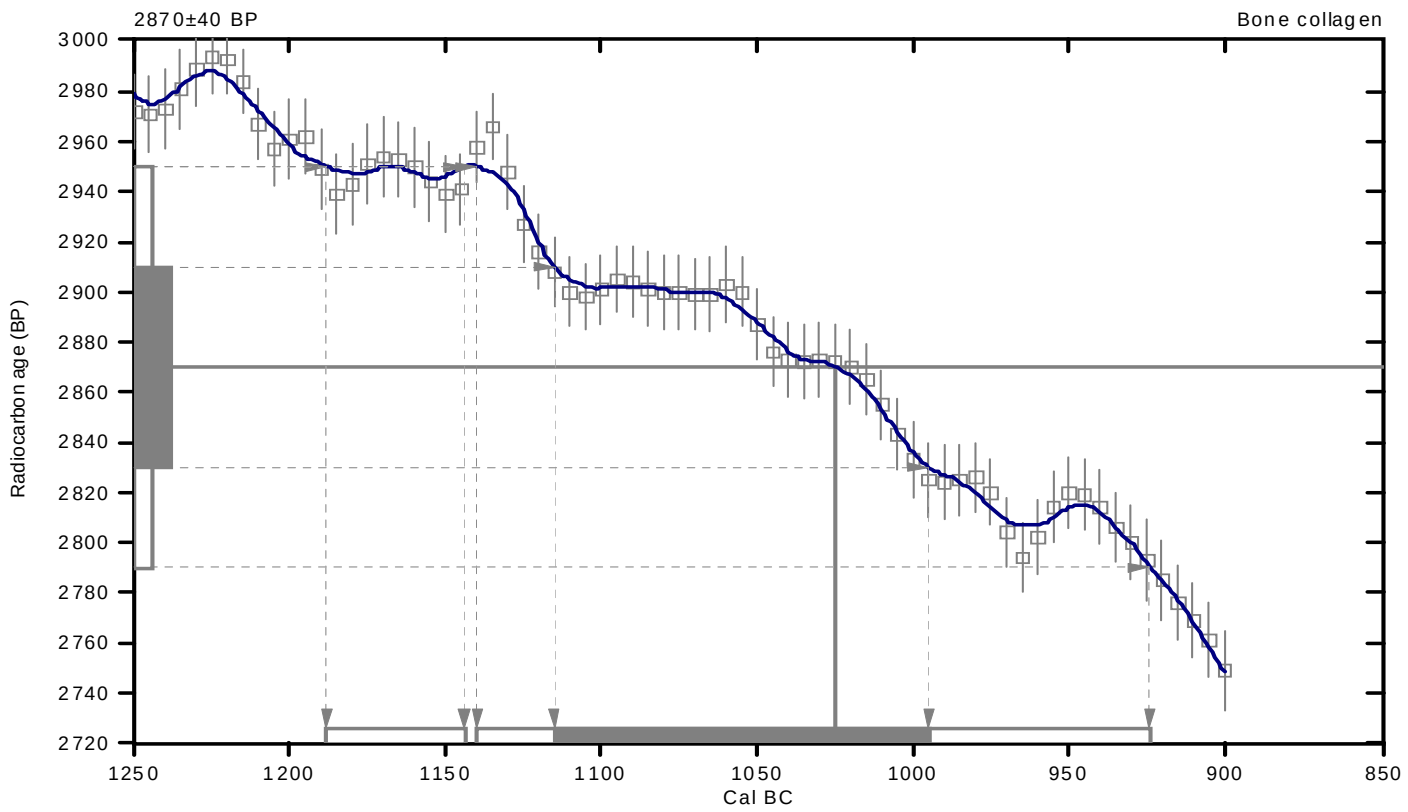
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.1:lab. mult=1)

Laboratory number:	**Beta-306773**
Conventional radiocarbon age:	**2870±40 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 1190 to 1140 (Cal BP 3140 to 3090) and Cal BC 1140 to 920 (Cal BP 3090 to 2870)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 1020 (Cal BP 2980)
1 Sigma calibrated result: (68% probability)	Cal BC 1120 to 1000 (Cal BP 3060 to 2940)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

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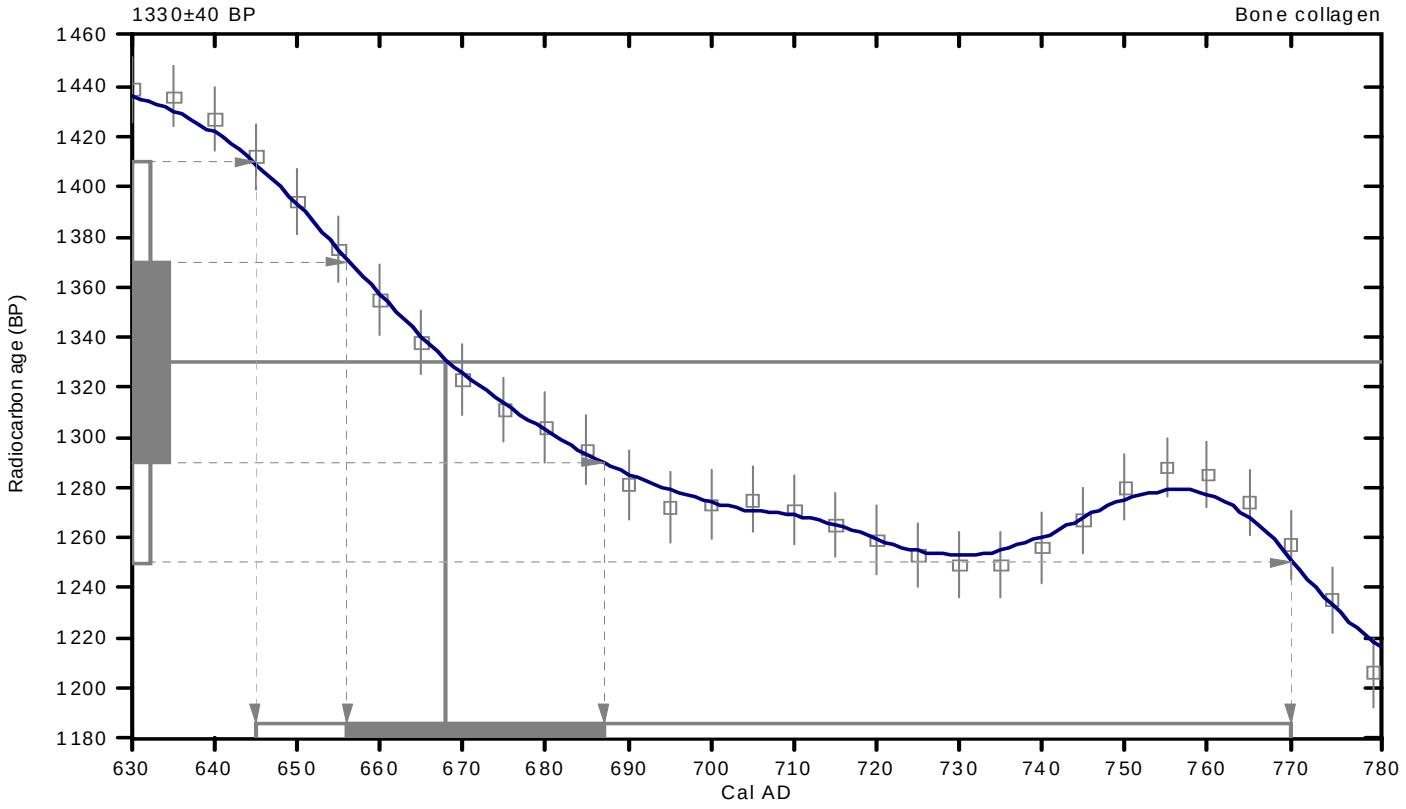
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.5:lab. mult=1)

Laboratory number:	**Beta-306774**
Conventional radiocarbon age:	**1330±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 640 to 770 (Cal BP 1300 to 1180)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 670 (Cal BP 1280)
1 Sigma calibrated result: (68% probability)	Cal AD 660 to 690 (Cal BP 1290 to 1260)



References:

Database used

INTCAL04

Calibration Database

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IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

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4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

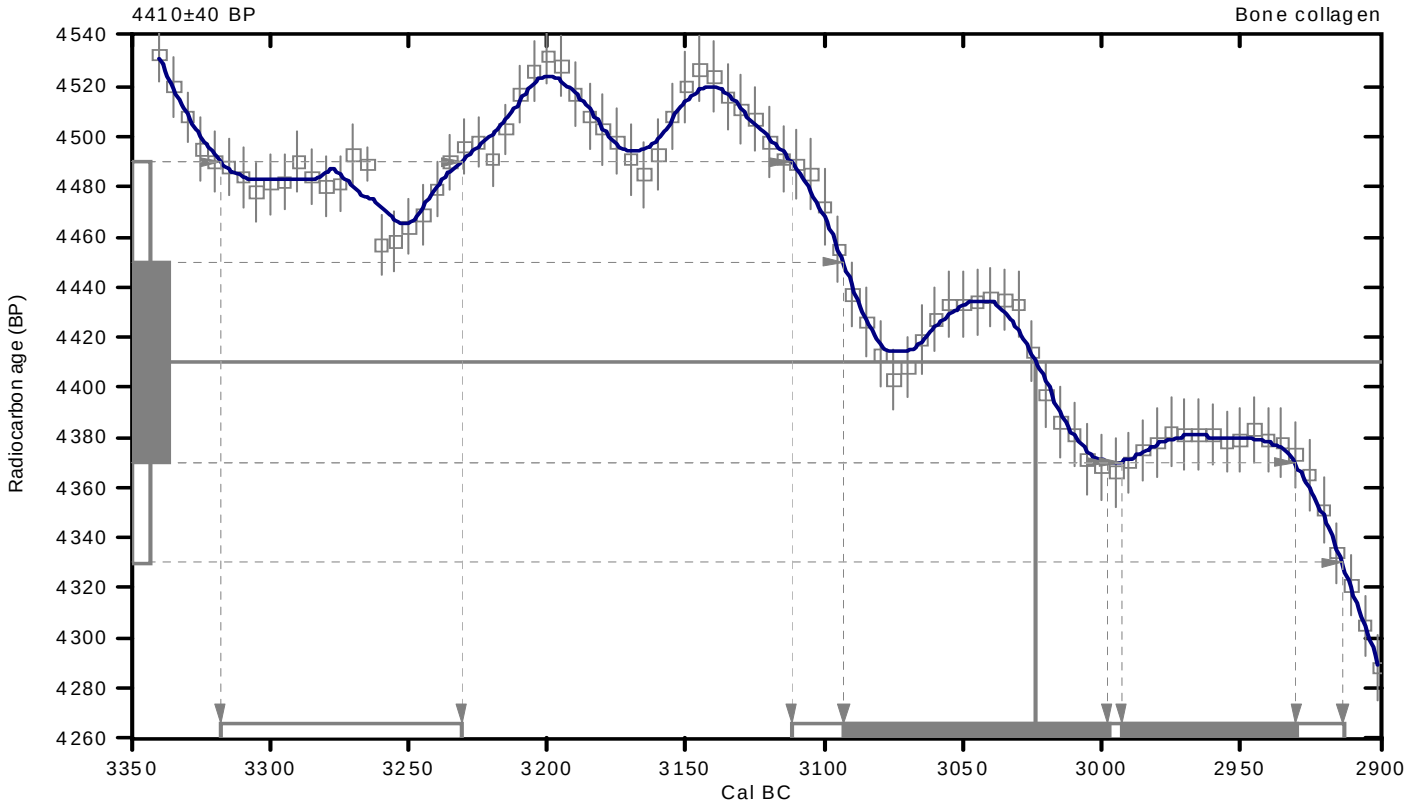
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-20.7:lab. mult=1)

Laboratory number:	**Beta-306775**
Conventional radiocarbon age:	**4410±40 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 3320 to 3230 (Cal BP 5270 to 5180) and Cal BC 3110 to 2910 (Cal BP 5060 to 4860)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 3020 (Cal BP 4970)
1 Sigma calibrated results: (68% probability)	Cal BC 3090 to 3000 (Cal BP 5040 to 4950) and Cal BC 2990 to 2930 (Cal BP 4940 to 4880)



References:

Database used

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IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

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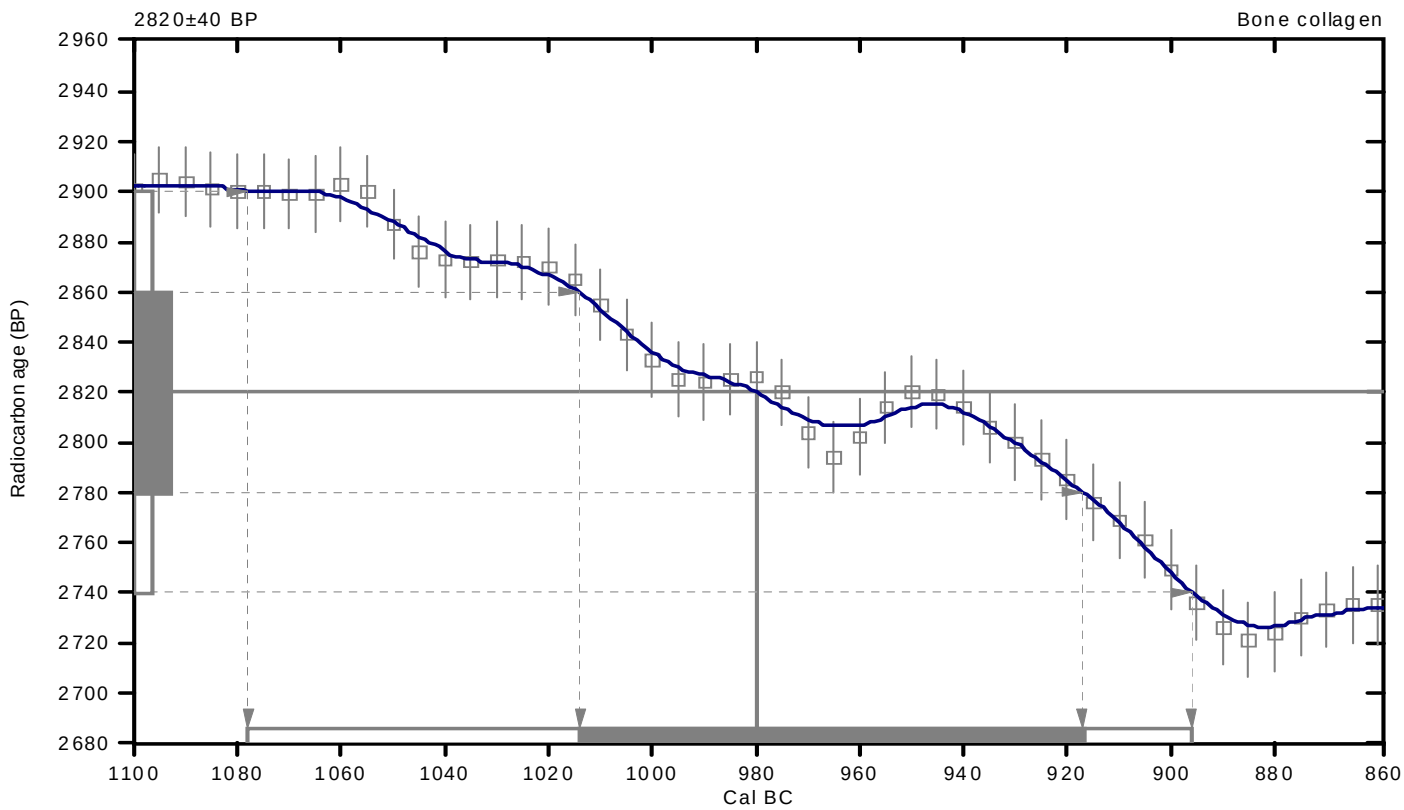
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.2:lab. mult=1)

Laboratory number:	**Beta-306776**
Conventional radiocarbon age:	**2820±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 1080 to 900 (Cal BP 3030 to 2850)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 980 (Cal BP 2930)
1 Sigma calibrated result: (68% probability)	Cal BC 1010 to 920 (Cal BP 2960 to 2870)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

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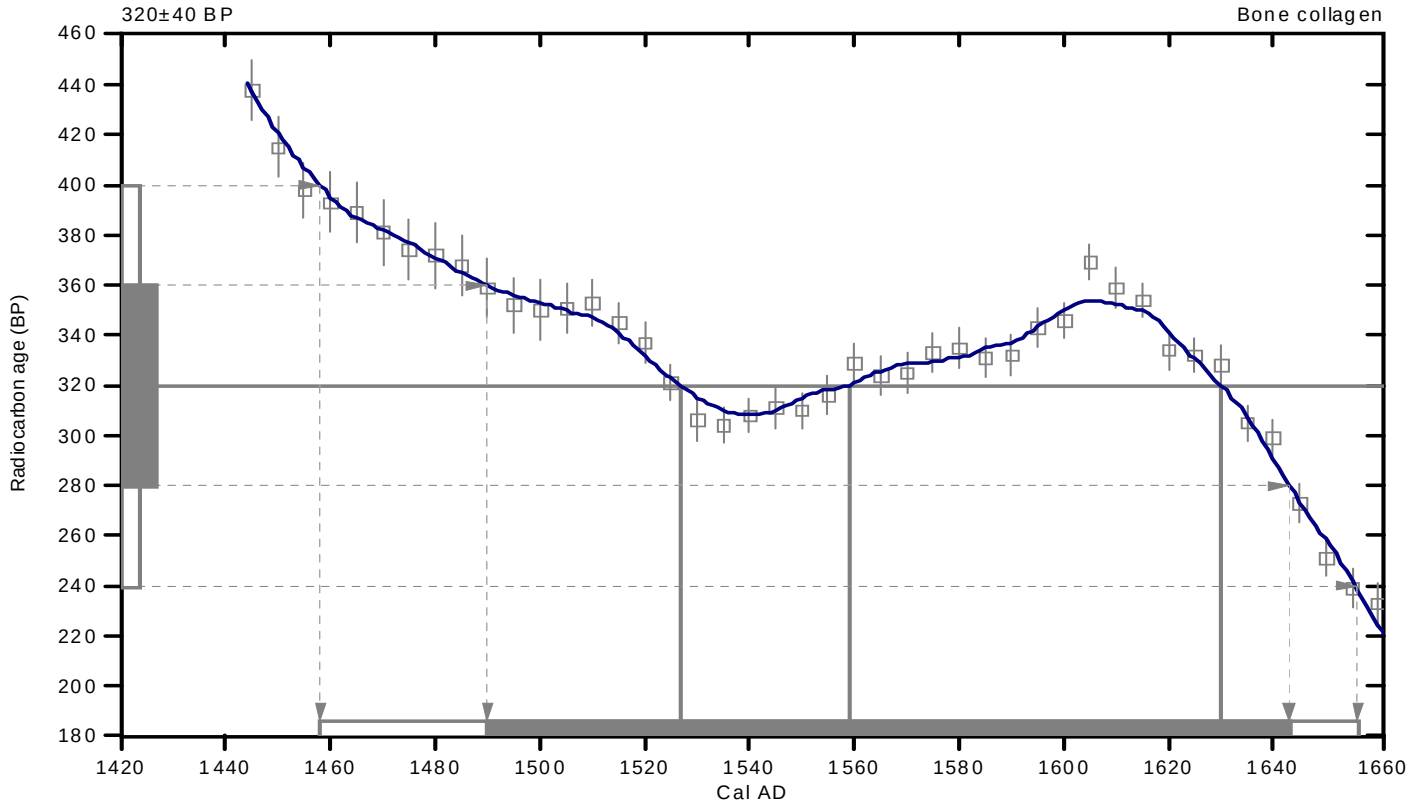
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-20.9:lab. mult=1)

Laboratory number:	**Beta-306777**
Conventional radiocarbon age:	**320±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 1460 to 1660 (Cal BP 490 to 290)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal AD 1530 (Cal BP 420) and Cal AD 1560 (Cal BP 390) and Cal AD 1630 (Cal BP 320)
1 Sigma calibrated result: (68% probability)	Cal AD 1490 to 1640 (Cal BP 460 to 310)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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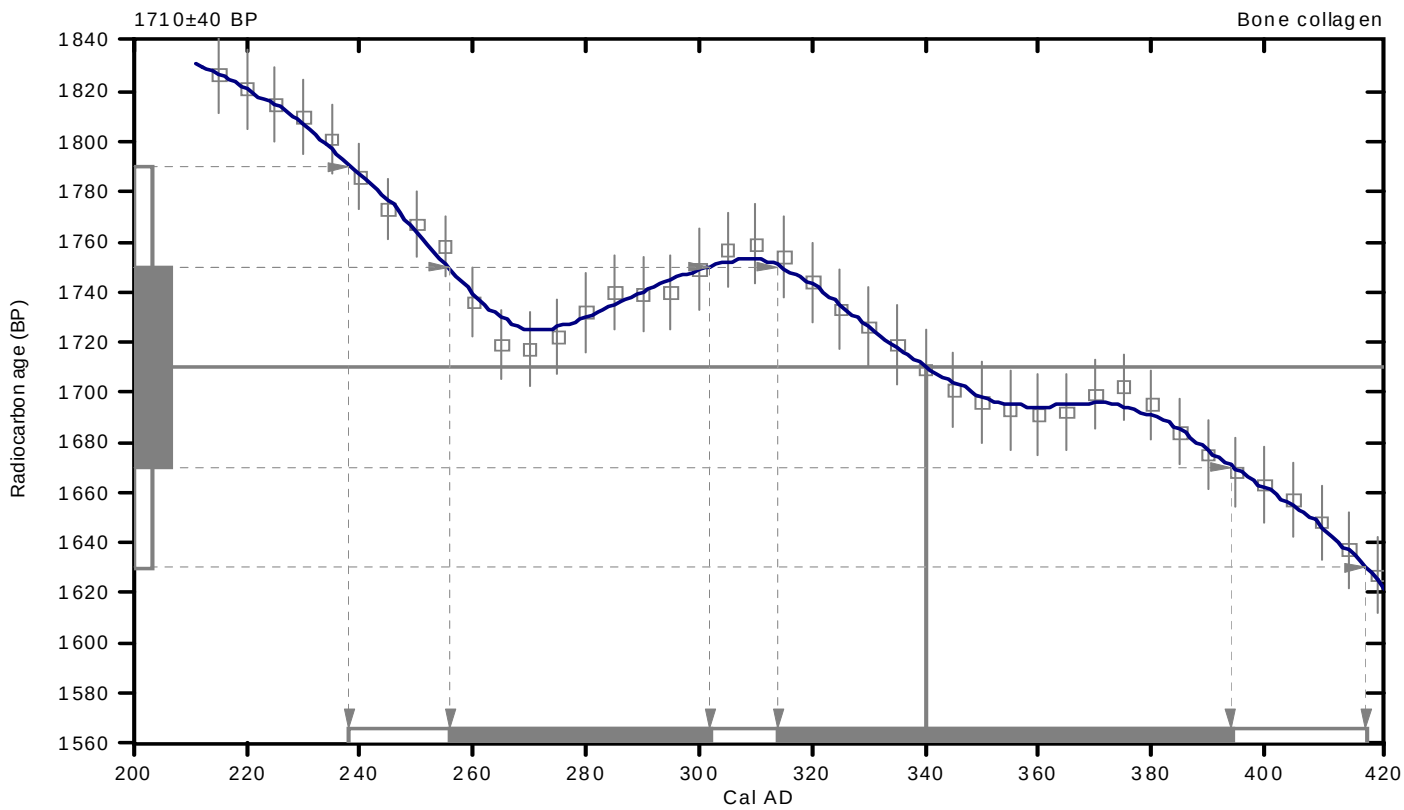
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-20.7:lab. mult=1)

Laboratory number:	**Beta-306778**
Conventional radiocarbon age:	**1710±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 240 to 420 (Cal BP 1710 to 1530)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 340 (Cal BP 1610)
1 Sigma calibrated results: (68% probability)	Cal AD 260 to 300 (Cal BP 1690 to 1650) and Cal AD 310 to 390 (Cal BP 1640 to 1560)



References:

Database used

INTCAL04

Calibration Database

INTCAL04 Radiocarbon Age Calibration

IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

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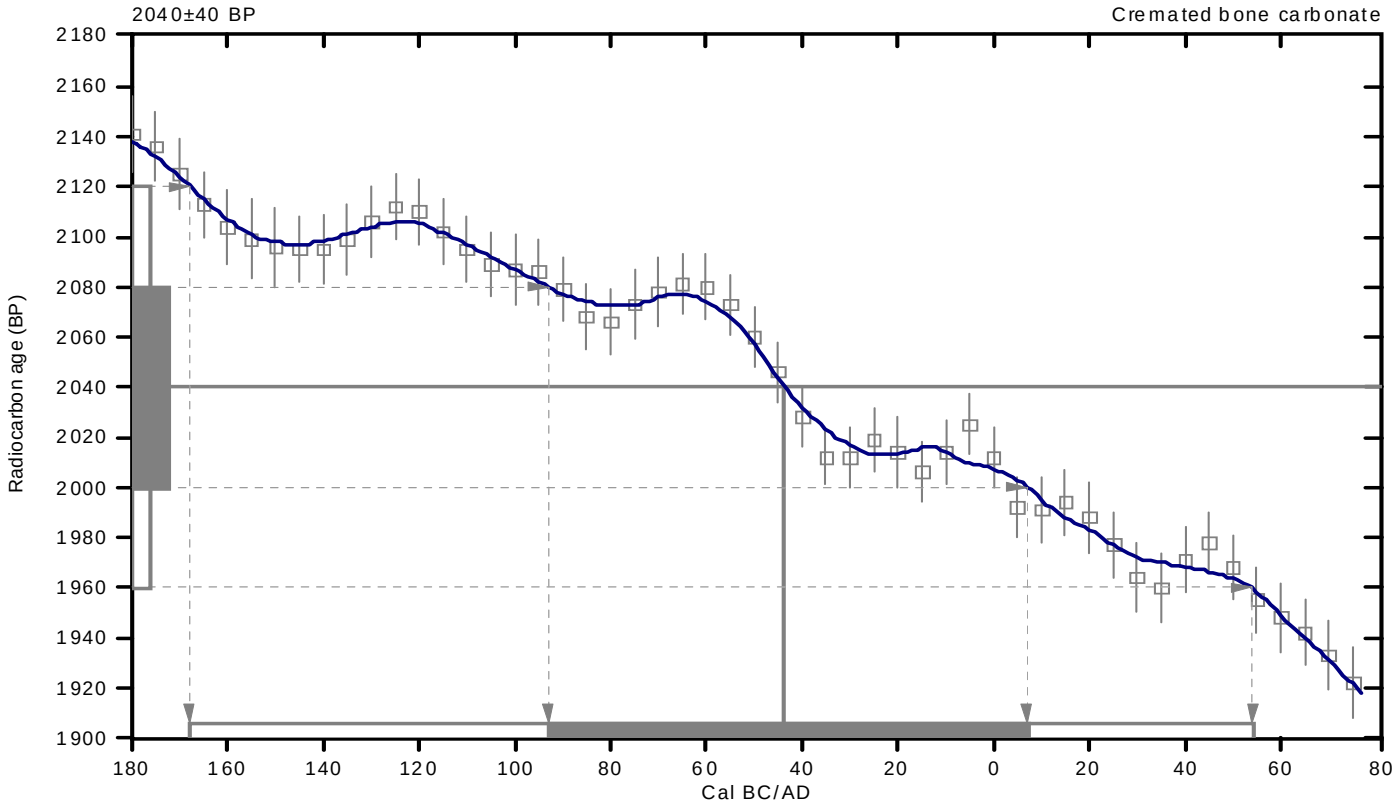
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.1:lab. mult=1)

Laboratory number:	**Beta-306779**
Conventional radiocarbon age:	**2040±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 170 to Cal AD 50 (Cal BP 2120 to 1900)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 40 (Cal BP 1990)
1 Sigma calibrated result: (68% probability)	Cal BC 90 to Cal AD 10 (Cal BP 2040 to 1940)



References:

Database used

INTCAL04

Calibration Database

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IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).

Mathematics

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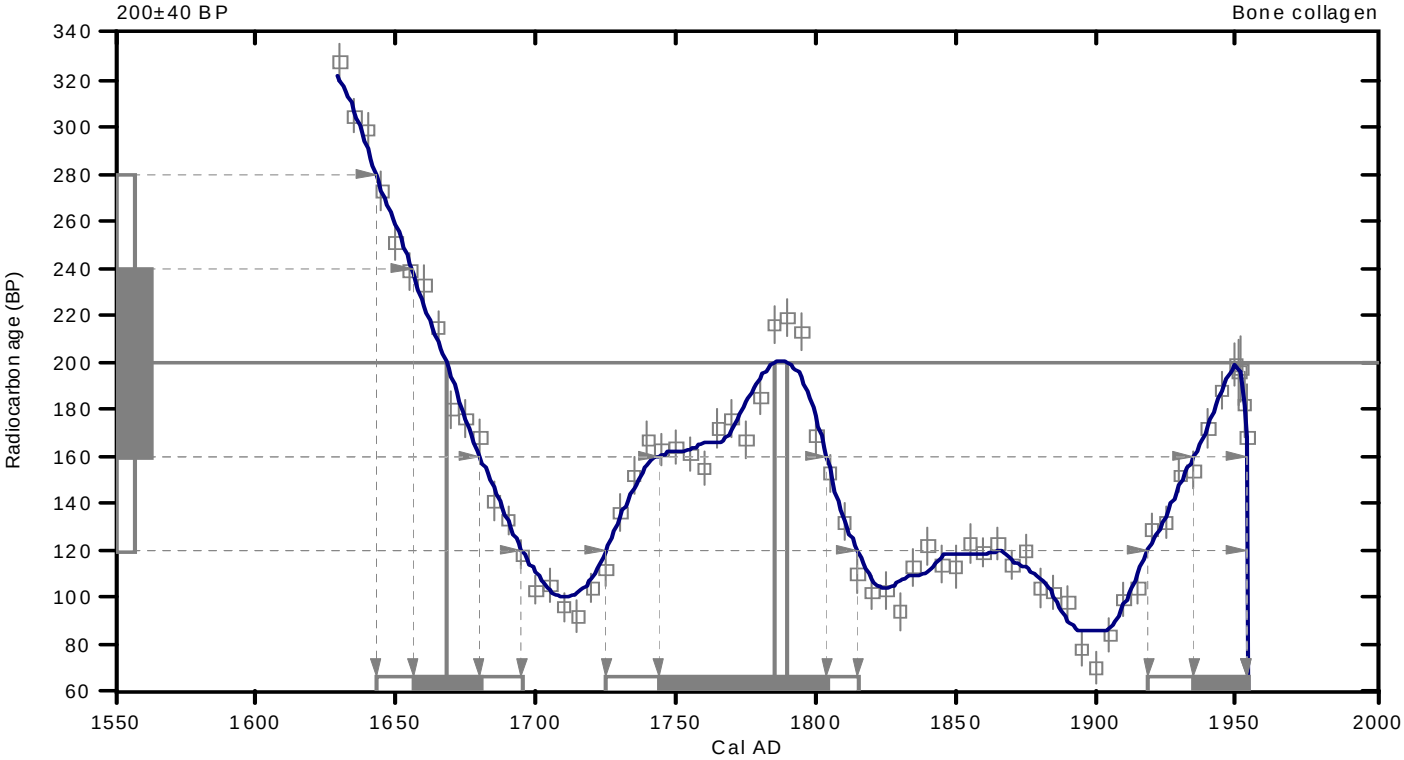
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-19.3:lab. mult=1)

Laboratory number:	**Beta-306780**
Conventional radiocarbon age:	**200±40 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 1640 to 1700 (Cal BP 310 to 260) and Cal AD 1720 to 1820 (Cal BP 220 to 140) and Cal AD 1920 to 1950 (Cal BP 30 to 0)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal AD 1670 (Cal BP 280) and Cal AD 1780 (Cal BP 160) and Cal AD 1790 (Cal BP 160)
1 Sigma calibrated results: (68% probability)	Cal AD 1660 to 1680 (Cal BP 290 to 270) and Cal AD 1740 to 1800 (Cal BP 210 to 150) and Cal AD 1940 to 1950 (Cal BP 20 to 0)



References:

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INTCAL04

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President

Ronald Hatfield
Christopher Patrick
Deputy Directors

September 17, 2012

Ms. Nova Pierson
AMEC Environment and Infrastructure
600-4445 Lougheed Highway
Burnaby, BC V5C 0E4
Canada

RE: Radiocarbon Dating Results For Samples ARD121145677, HBRH55-45802

Dear Dr. Pierson:

Enclosed are the radiocarbon dating results for two samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the MASTERCARD card provided. A receipt is enclosed. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Ms. Nova Pierson — Report Date: 9/17/2012

AMEC Environment and Infrastructure — Material Received: 9/10/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 330002 SAMPLE : ARD121145677 ANALYSIS : AMS-PRIORITY delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid	70 +/- 30 BP	-26.7 o/oo	40 +/- 30 BP
Beta - 330013 SAMPLE : HBRH55-45802 ANALYSIS : AMS-PRIORITY delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 350 to 320 (Cal BP 2300 to 2270) AND Cal BC 210 to 90 (Cal BP 2160 to 2040) Cal BC 80 to 50 (Cal BP 2030 to 2000)	2160 +/- 30 BP	-26.8 o/oo	2130 +/- 30 BP

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

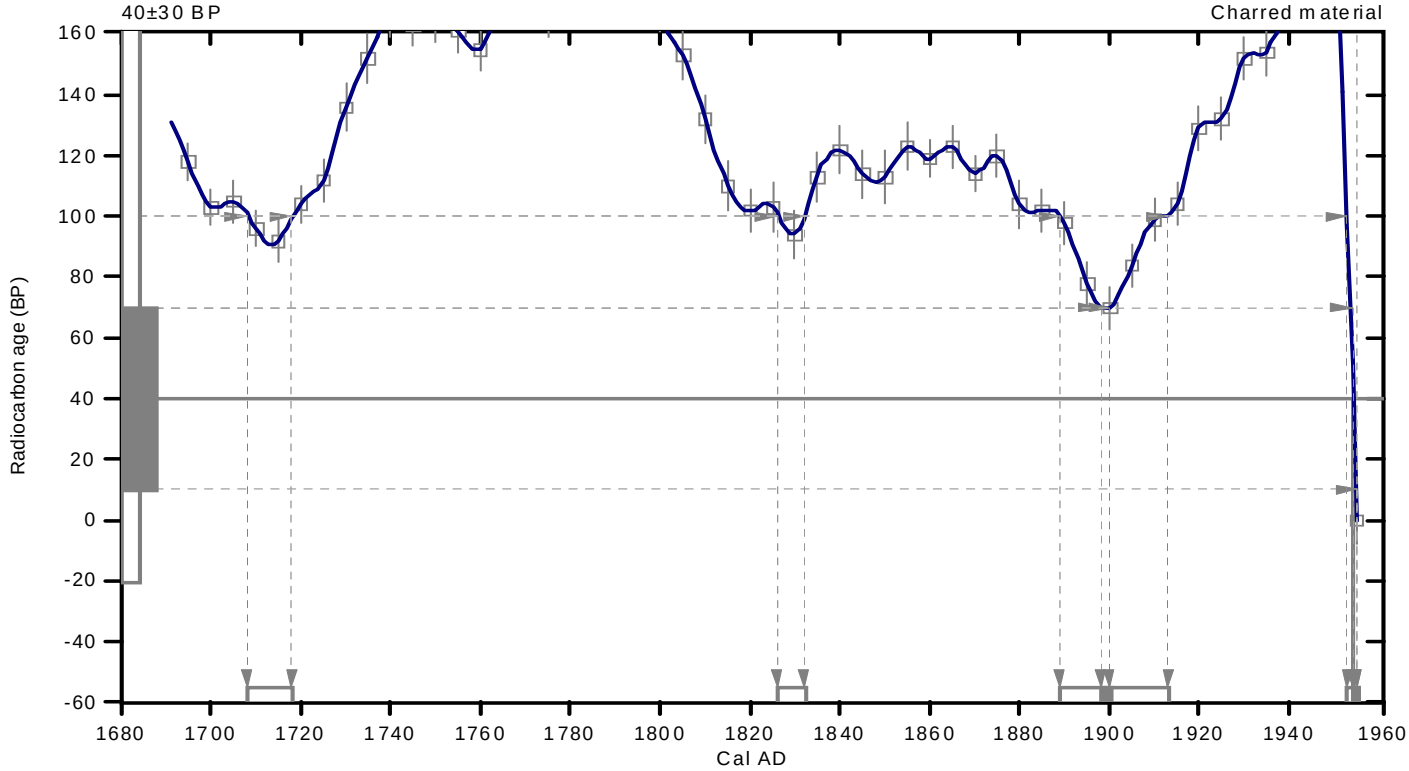
(Variables: C13/C12=-26.7:lab. mult=1)

Laboratory number:	**Beta-330002**
Conventional radiocarbon age:	**40±30 BP**
2 Sigma calibrated results[2]: (95% probability)	**Cal AD 1710 to 1720 (Cal BP 240 to 230) and Cal AD 1830 to 1830 (Cal BP 120 to 120) and Cal AD 1890 to 1910 (Cal BP 60 to 40) and Cal AD Post 1950**

[2] 2 Sigma range being quoted is the maximum antiquity based on the minus 2 Sigma range

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD Post 1950
1 Sigma calibrated results: (68% probability)	Cal AD 1900 to 1900 (Cal BP 50 to 50) and Cal AD Post 1950



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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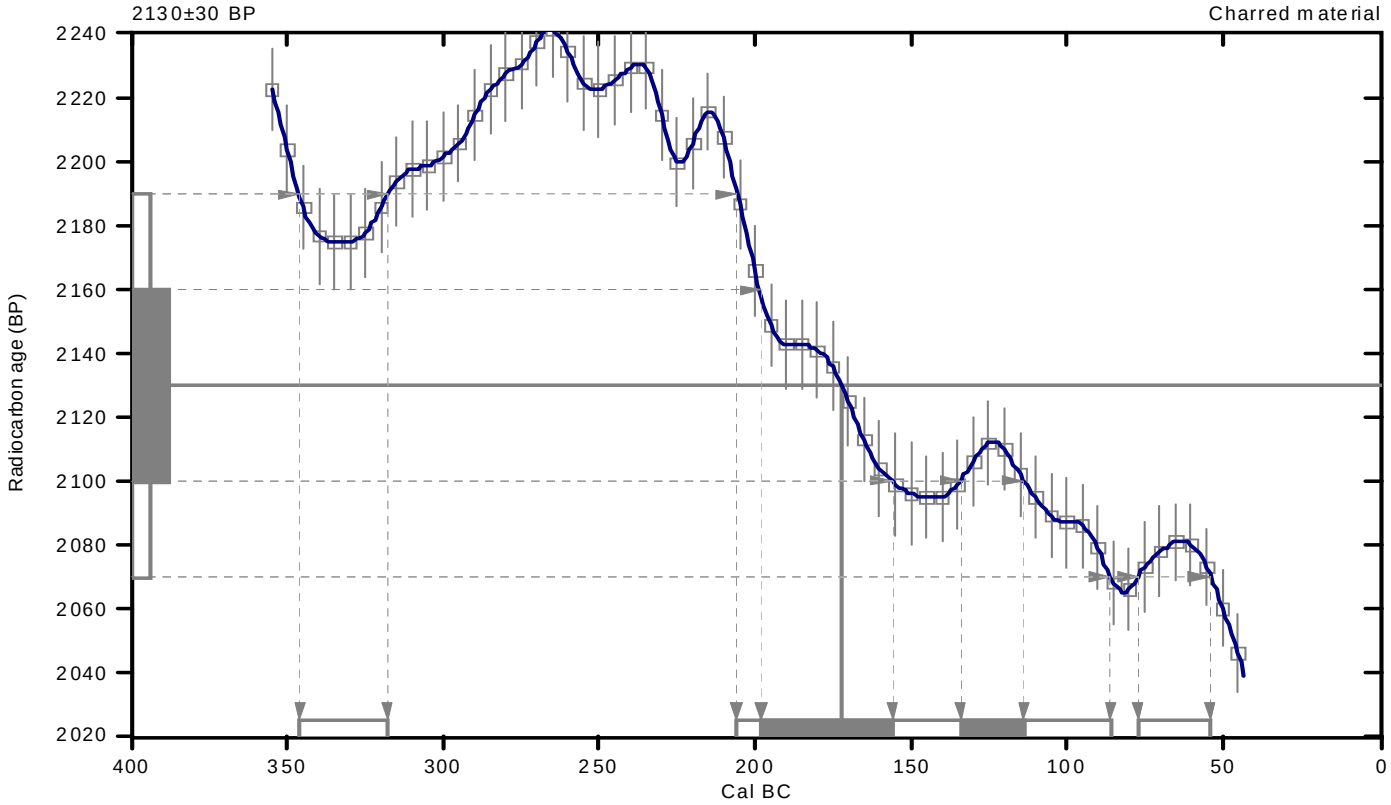
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26.8:lab. mult=1)

Laboratory number:	**Beta-330013**
Conventional radiocarbon age:	**2130±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 350 to 320 (Cal BP 2300 to 2270) and Cal BC 210 to 90 (Cal BP 2160 to 2040) and Cal BC 80 to 50 (Cal BP 2030 to 2000)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 170 (Cal BP 2120)
1 Sigma calibrated results: (68% probability)	Cal BC 200 to 160 (Cal BP 2150 to 2110) and Cal BC 130 to 110 (Cal BP 2080 to 2060)



References:

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Mathematics used for calibration scenario

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Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

September 18, 2012

Ms. Nova Pierson
AMEC Environment and Infrastructure
600-4445 Lougheed Highway
Burnaby, BC V5C 0E4
Canada

RE: Radiocarbon Dating Results For Samples ASLP122-2, GMY129-45172, HBRH12-45883, HBRI6-45175

Dear Dr. Pierson:

Enclosed are the radiocarbon dating results for four samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the MASTERCARD card provided. A receipt is enclosed. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Ms. Nova Pierson — Report Date: 9/18/2012

AMEC Environment and Infrastructure — Material Received: 9/10/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 330004	3320 +/- 40 BP	-24.2 o/oo	3330 +/- 40 BP

SAMPLE : ASLP122-2
ANALYSIS : AMS-PRIORITY delivery
MATERIAL/PRETREATMENT : (cremated bone carbonate): bone carbonate extraction
2 SIGMA CALIBRATION : Cal BC 1730 to 1710 (Cal BP 3680 to 3660) AND Cal BC 1690 to 1510 (Cal BP 3640 to 3460)

Beta - 330005	100 +/- 30 BP	-23.1 o/oo	130 +/- 30 BP

SAMPLE : GMY129-45172
ANALYSIS : AMS-PRIORITY delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal AD 1670 to 1780 (Cal BP 280 to 170) AND Cal AD 1800 to 1900 (Cal BP 150 to 50)
Cal AD 1900 to 1940 (Cal BP 50 to 0) AND Cal AD 1950 to post 1950 (Cal BP 0 to post 1950)

Beta - 330008	100.1 +/- 0.4 pMC	-21.1 o/oo	50 +/- 30 BP

SAMPLE : HBRH12-45883
ANALYSIS : AMS-PRIORITY delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali

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Beta - 330014	4610 +/- 40 BP	-24.3 o/oo	4620 +/- 40 BP

SAMPLE : HBRI6-45175
ANALYSIS : AMS-PRIORITY delivery
MATERIAL/PRETREATMENT : (cremated bone carbonate): bone carbonate extraction
2 SIGMA CALIBRATION : Cal BC 3510 to 3420 (Cal BP 5460 to 5370) AND Cal BC 3420 to 3410 (Cal BP 5360 to 5360)
Cal BC 3400 to 3400 (Cal BP 5350 to 5350) AND Cal BC 3380 to 3350 (Cal BP 5330 to 5300)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

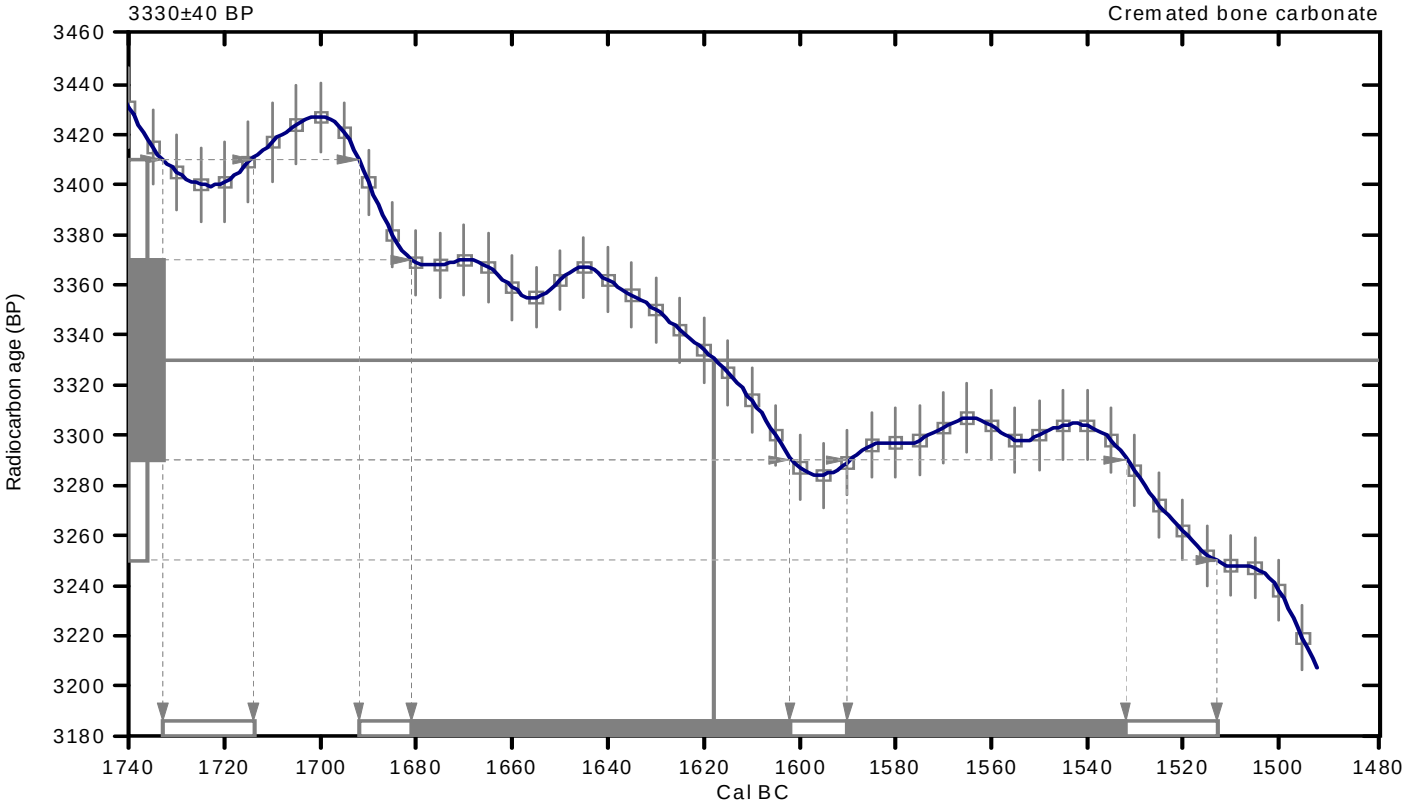
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.2:lab. mult=1)

Laboratory number:	**Beta-330004**
Conventional radiocarbon age:	**3330±40 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 1730 to 1710 (Cal BP 3680 to 3660) and Cal BC 1690 to 1510 (Cal BP 3640 to 3460)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 1620 (Cal BP 3570)
1 Sigma calibrated results: (68% probability)	Cal BC 1680 to 1600 (Cal BP 3630 to 3550) and Cal BC 1590 to 1530 (Cal BP 3540 to 3480)



References:

Database used

INTCAL09

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Mathematics used for calibration scenario

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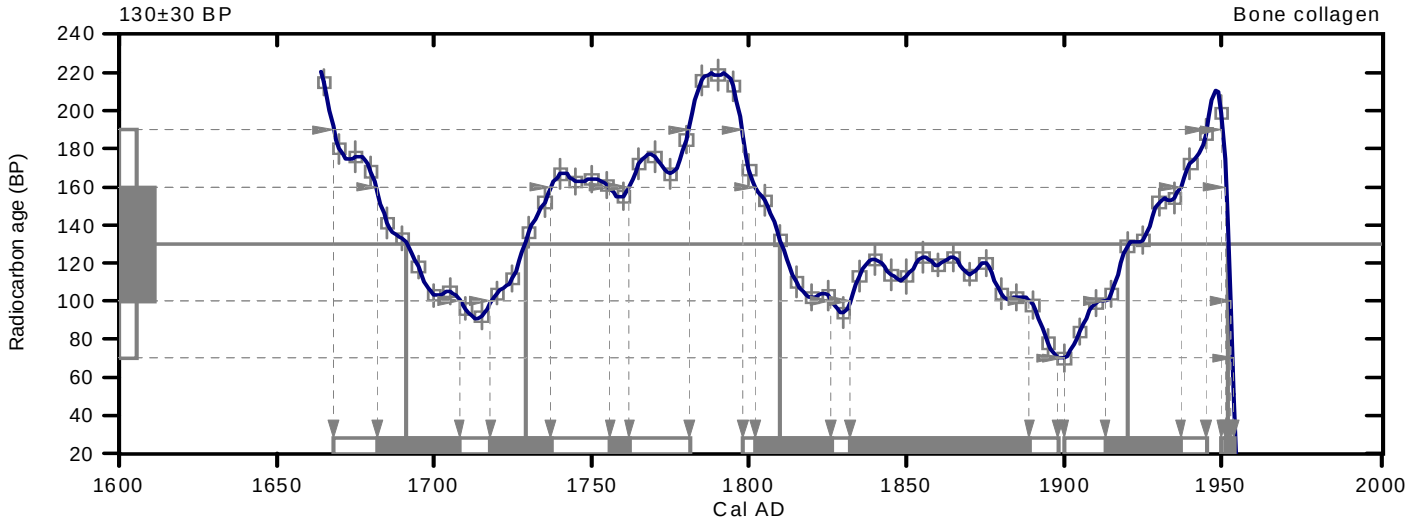
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.1:lab. mult=1)

Laboratory number:	**Beta-330005**
Conventional radiocarbon age:	**130±30 BP**
2 Sigma calibrated results: **(95% probability)**	**Cal AD 1670 to 1780 (Cal BP 280 to 170) and** **Cal AD 1800 to 1900 (Cal BP 150 to 50) and** **Cal AD 1900 to 1940 (Cal BP 50 to 0) and** **Cal AD 1950 to post 1950 (Cal BP 0 to post 1950)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal AD 1690 (Cal BP 260) and Cal AD 1730 (Cal BP 220) and Cal AD 1810 (Cal BP 140) and Cal AD 1920 (Cal BP 30) and Cal AD Post 1950
1 Sigma calibrated results: (68% probability)	Cal AD 1680 to 1710 (Cal BP 270 to 240) and Cal AD 1720 to 1740 (Cal BP 230 to 210) and Cal AD 1760 to 1760 (Cal BP 190 to 190) and Cal AD 1800 to 1830 (Cal BP 150 to 120) and Cal AD 1830 to 1890 (Cal BP 120 to 60) and Cal AD 1910 to 1940 (Cal BP 40 to 10) and Cal AD Post 1950



References:

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

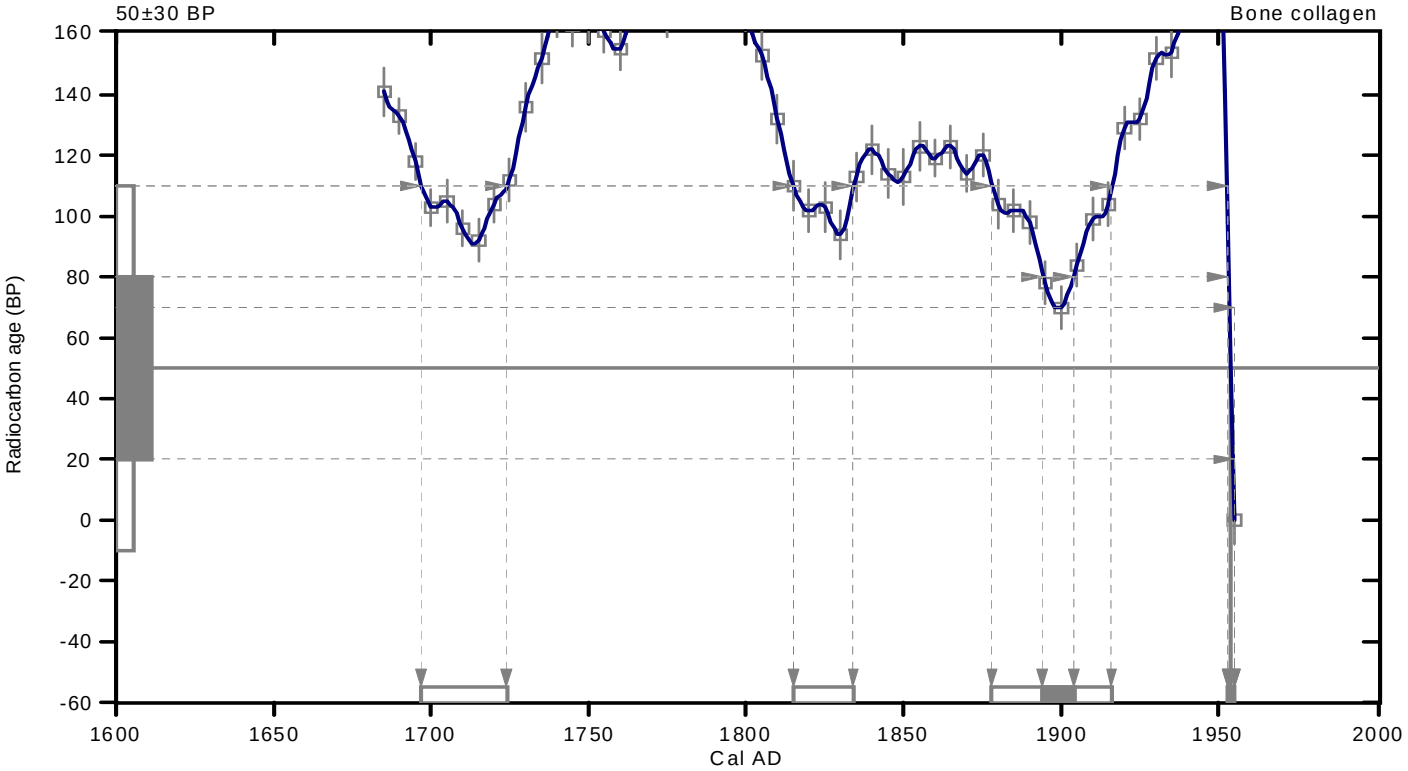
(Variables: C13/C12=-21.1:lab. mult=1)

Laboratory number:	**Beta-330008**
Conventional radiocarbon age:	**50±30 BP**
2 Sigma calibrated results[2]: (95% probability)	**Cal AD 1700 to 1720 (Cal BP 250 to 230) and Cal AD 1820 to 1830 (Cal BP 140 to 120) and Cal AD 1880 to 1920 (Cal BP 70 to 30) and Cal AD Post 1950**

[2] 2 Sigma range being quoted is the maximum antiquity based on the minus 2 Sigma range

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD Post 1950
1 Sigma calibrated results: (68% probability)	Cal AD 1890 to 1900 (Cal BP 60 to 50) and Cal AD Post 1950



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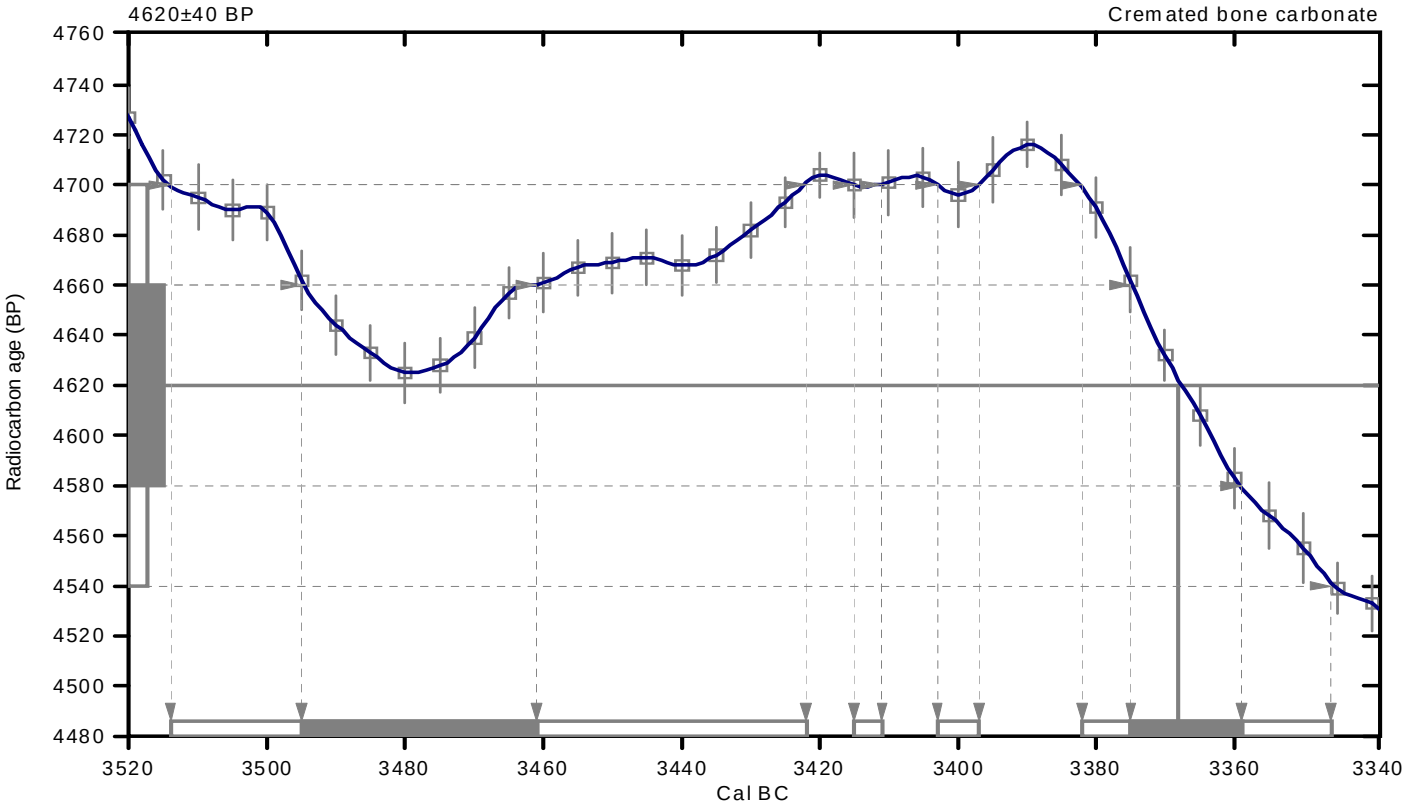
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.3:lab. mult=1)

Laboratory number:	**Beta-330014**
Conventional radiocarbon age:	**4620±40 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 3510 to 3420 (Cal BP 5460 to 5370) and Cal BC 3420 to 3410 (Cal BP 5360 to 5360) and Cal BC 3400 to 3400 (Cal BP 5350 to 5350) and Cal BC 3380 to 3350 (Cal BP 5330 to 5300)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 3370 (Cal BP 5320)
1 Sigma calibrated results: (68% probability)	Cal BC 3500 to 3460 (Cal BP 5440 to 5410) and Cal BC 3380 to 3360 (Cal BP 5320 to 5310)



References:

Database used

INTCAL09

References to INTCAL09 database

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Christopher Patrick
Deputy Directors

September 20, 2012

Ms. Nova Pierson
AMEC Environment and Infrastructure
600-4445 Lougheed Highway
Burnaby, BC V5C 0E4
Canada

RE: Radiocarbon Dating Results For Samples HARJ14-45443, HBRH12-45999, HBRH27-45999

Dear Dr. Pierson:

Enclosed are the radiocarbon dating results for three samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Ms. Nova Pierson — Report Date: 9/20/2012

AMEC Environment and Infrastructure — Material Received: 9/10/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 330006	2390 +/- 30 BP	-21.8 o/oo	2440 +/- 30 BP
SAMPLE : HARJ14-45443			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali			
2 SIGMA CALIBRATION : Cal BC 750 to 680 (Cal BP 2700 to 2630) AND Cal BC 670 to 610 (Cal BP 2620 to 2560) Cal BC 600 to 400 (Cal BP 2550 to 2360)			
Beta - 330009	135.8 +/- 0.3 pMC	-23.1 o/oo	135.3 +/- 0.3 pMC
SAMPLE : HBRH12-45999			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali			
Beta - 330011	1810 +/- 30 BP	-23.1 o/oo	1840 +/- 30 BP
SAMPLE : HBRH27-45999			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali			
2 SIGMA CALIBRATION : Cal AD 80 to 240 (Cal BP 1860 to 1710)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

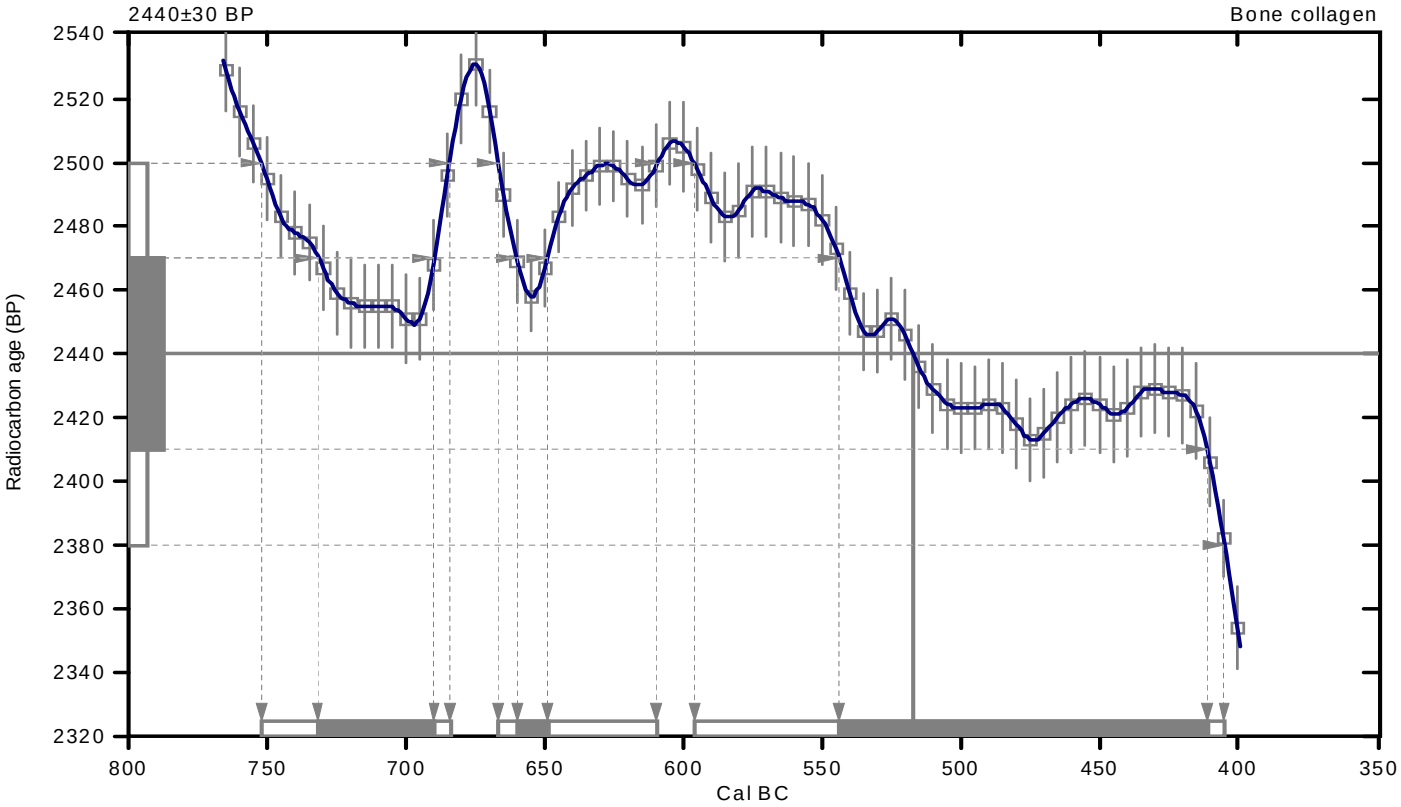
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.8:lab. mult=1)

Laboratory number:	**Beta-330006**
Conventional radiocarbon age:	**2440±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 750 to 680 (Cal BP 2700 to 2630) and Cal BC 670 to 610 (Cal BP 2620 to 2560) and Cal BC 600 to 400 (Cal BP 2550 to 2360)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 520 (Cal BP 2470)
1 Sigma calibrated results: (68% probability)	Cal BC 730 to 690 (Cal BP 2680 to 2640) and Cal BC 660 to 650 (Cal BP 2610 to 2600) and Cal BC 540 to 410 (Cal BP 2490 to 2360)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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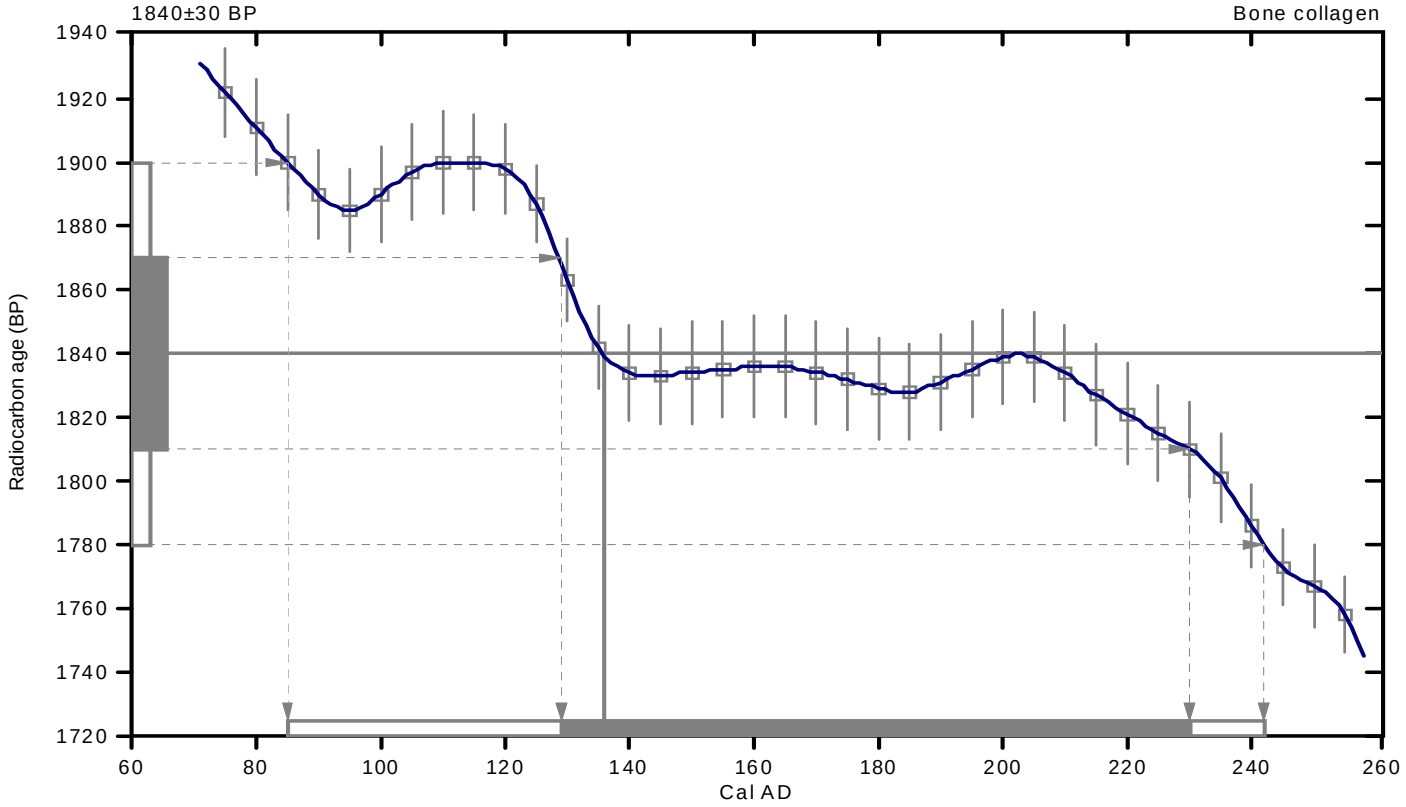
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.1:lab. mult=1)

Laboratory number:	**Beta-330011**
Conventional radiocarbon age:	**1840±30 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 80 to 240 (Cal BP 1860 to 1710)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 140 (Cal BP 1810)
1 Sigma calibrated result: (68% probability)	Cal AD 130 to 230 (Cal BP 1820 to 1720)



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Database used

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Mathematics used for calibration scenario

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Beta Analytic Inc.
4985 SW 74 Court
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Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

September 25, 2012

Ms. Nova Pierson
AMEC Environment and Infrastructure
600-4445 Lougheed Highway
Burnaby, BC V5C 0E4
Canada

RE: Radiocarbon Dating Results For Samples HARK16T155, HARK16T1105, HARK16-T2125, HARK23T145, HARK23T2100, HARK23T2125

Dear Dr. Pierson:

Enclosed are the radiocarbon dating results for six samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Thank you for prepaying the analyses. A receipt is enclosed. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
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beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Ms. Nova Pierson — Report Date: 9/25/2012

AMEC Environment and Infrastructure — Material Received: 9/17/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 330449	1810 +/- 30 BP	-23.0 o/oo	1840 +/- 30 BP
SAMPLE : HARK16T155			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 80 to 240 (Cal BP 1860 to 1710)			
Beta - 330450	2400 +/- 30 BP	-24.0 o/oo	2420 +/- 30 BP
SAMPLE : HARK16T1105			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal BC 740 to 690 (Cal BP 2690 to 2640) AND Cal BC 660 to 650 (Cal BP 2610 to 2600) Cal BC 550 to 400 (Cal BP 2500 to 2350)			
Beta - 330451	2820 +/- 30 BP	-22.0 o/oo	2870 +/- 30 BP
SAMPLE : HARK16-T2125			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali			
2 SIGMA CALIBRATION : Cal BC 1130 to 970 (Cal BP 3080 to 2920) AND Cal BC 960 to 940 (Cal BP 2910 to 2890)			
Beta - 330452	1260 +/- 30 BP	-25.5 o/oo	1250 +/- 30 BP
SAMPLE : HARK23T145			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid			
2 SIGMA CALIBRATION : Cal AD 680 to 830 (Cal BP 1270 to 1120) AND Cal AD 840 to 870 (Cal BP 1110 to 1080)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

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MIAMI, FLORIDA, USA 33155
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REPORT OF RADIOCARBON DATING ANALYSES

Ms. Nova Pierson

Report Date: 9/25/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 330453	2250 +/- 30 BP	-23.4 o/oo	2280 +/- 30 BP
SAMPLE : HARK23T2100			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (cremated bone carbonate): bone carbonate extraction			
2 SIGMA CALIBRATION : Cal BC 400 to 350 (Cal BP 2350 to 2300) AND Cal BC 290 to 230 (Cal BP 2240 to 2180)			
Beta - 330454	2210 +/- 30 BP	-25.6 o/oo	2200 +/- 30 BP
SAMPLE : HARK23T2125			
ANALYSIS : AMS-PRIORITY delivery			
MATERIAL/PRETREATMENT : (cremated bone carbonate): bone carbonate extraction			
2 SIGMA CALIBRATION : Cal BC 380 to 180 (Cal BP 2330 to 2130)			

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

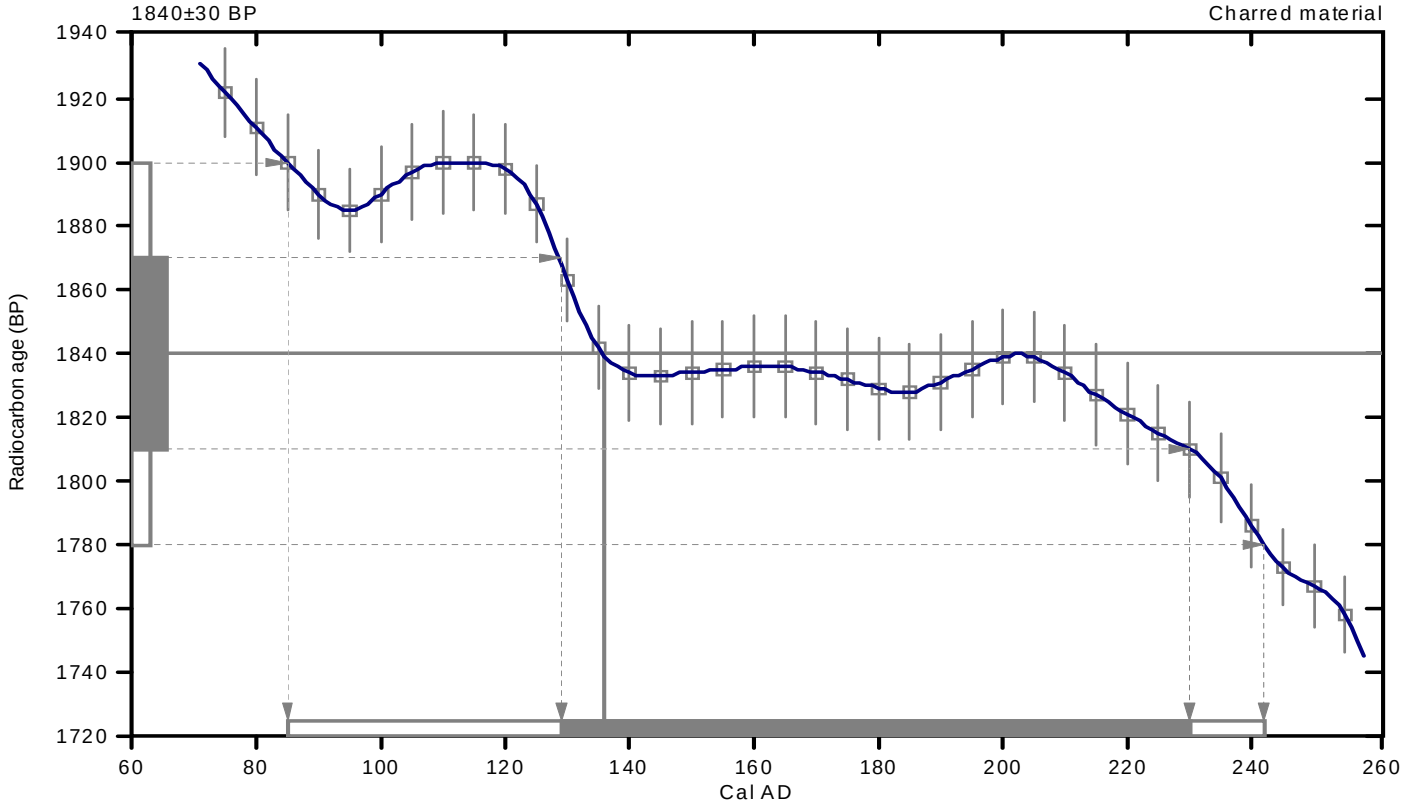
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23:lab. mult=1)

Laboratory number:	**Beta-330449**
Conventional radiocarbon age:	**1840±30 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 80 to 240 (Cal BP 1860 to 1710)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 140 (Cal BP 1810)
1 Sigma calibrated result: (68% probability)	Cal AD 130 to 230 (Cal BP 1820 to 1720)



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Mathematics used for calibration scenario

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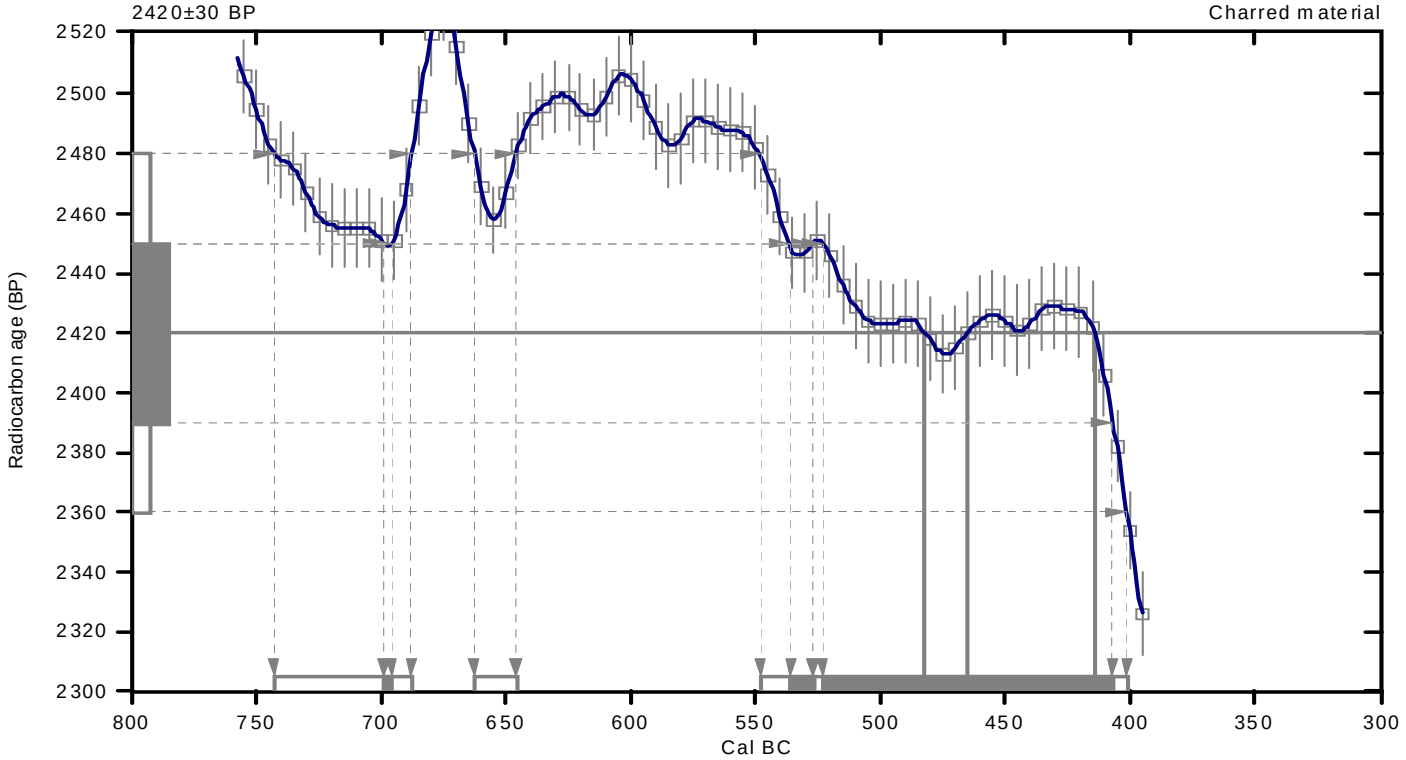
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24:lab. mult=1)

Laboratory number:	**Beta-330450**
Conventional radiocarbon age:	**2420±30 BP**
2 Sigma calibrated results: **(95% probability)**	**Cal BC 740 to 690 (Cal BP 2690 to 2640) and** **Cal BC 660 to 650 (Cal BP 2610 to 2600) and** **Cal BC 550 to 400 (Cal BP 2500 to 2350)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal BC 480 (Cal BP 2430) and Cal BC 460 (Cal BP 2420) and Cal BC 410 (Cal BP 2360)
1 Sigma calibrated results: (68% probability)	Cal BC 700 to 700 (Cal BP 2650 to 2650) and Cal BC 540 to 530 (Cal BP 2490 to 2480) and Cal BC 520 to 410 (Cal BP 2470 to 2360)



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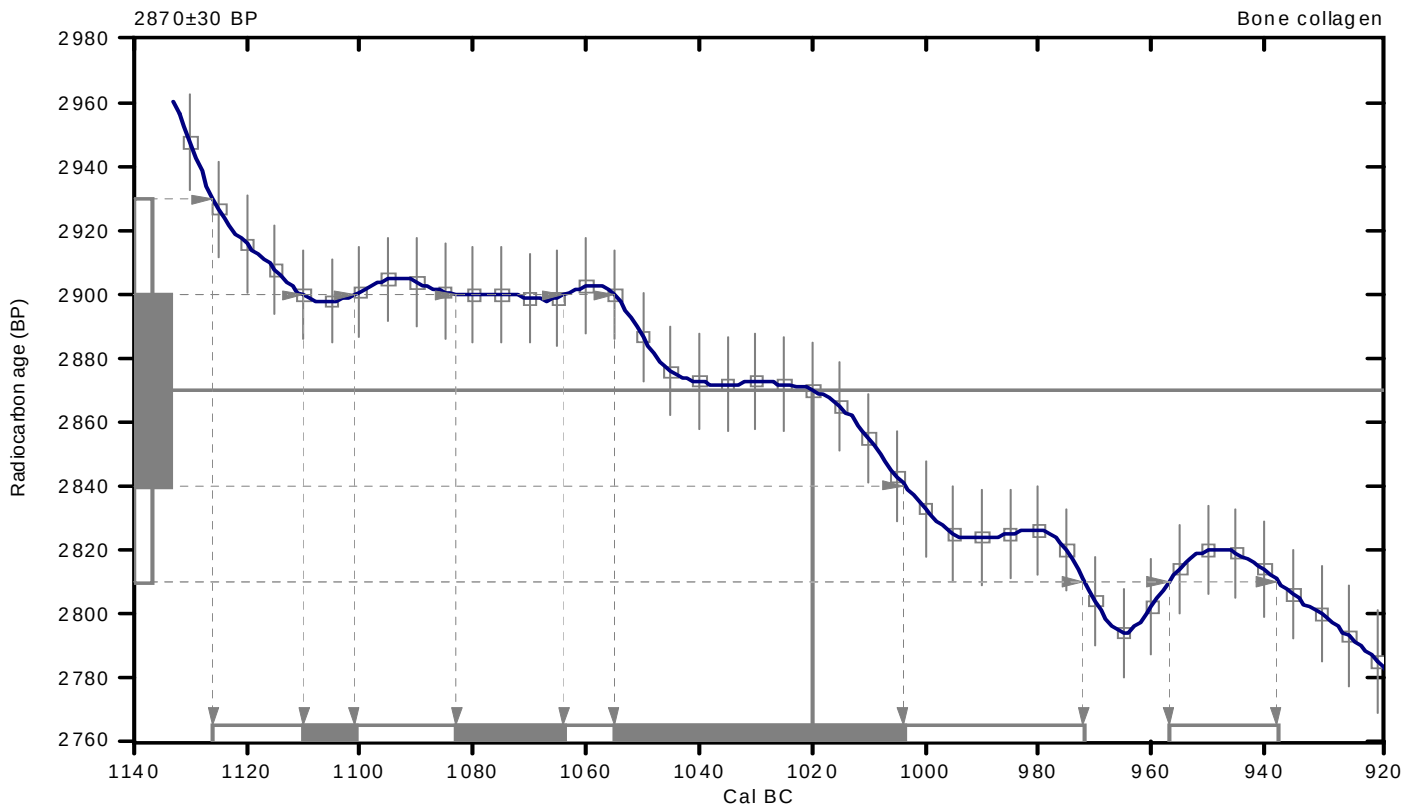
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22:lab. mult=1)

Laboratory number:	**Beta-330451**
Conventional radiocarbon age:	**2870±30 BP**
2 Sigma calibrated results: **(95% probability)**	**Cal BC 1130 to 970 (Cal BP 3080 to 2920) and Cal BC 960 to 940 (Cal BP 2910 to 2890)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 1020 (Cal BP 2970)
1 Sigma calibrated results: (68% probability)	Cal BC 1110 to 1100 (Cal BP 3060 to 3050) and Cal BC 1080 to 1060 (Cal BP 3030 to 3010) and Cal BC 1060 to 1000 (Cal BP 3000 to 2950)



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Database used

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Mathematics used for calibration scenario

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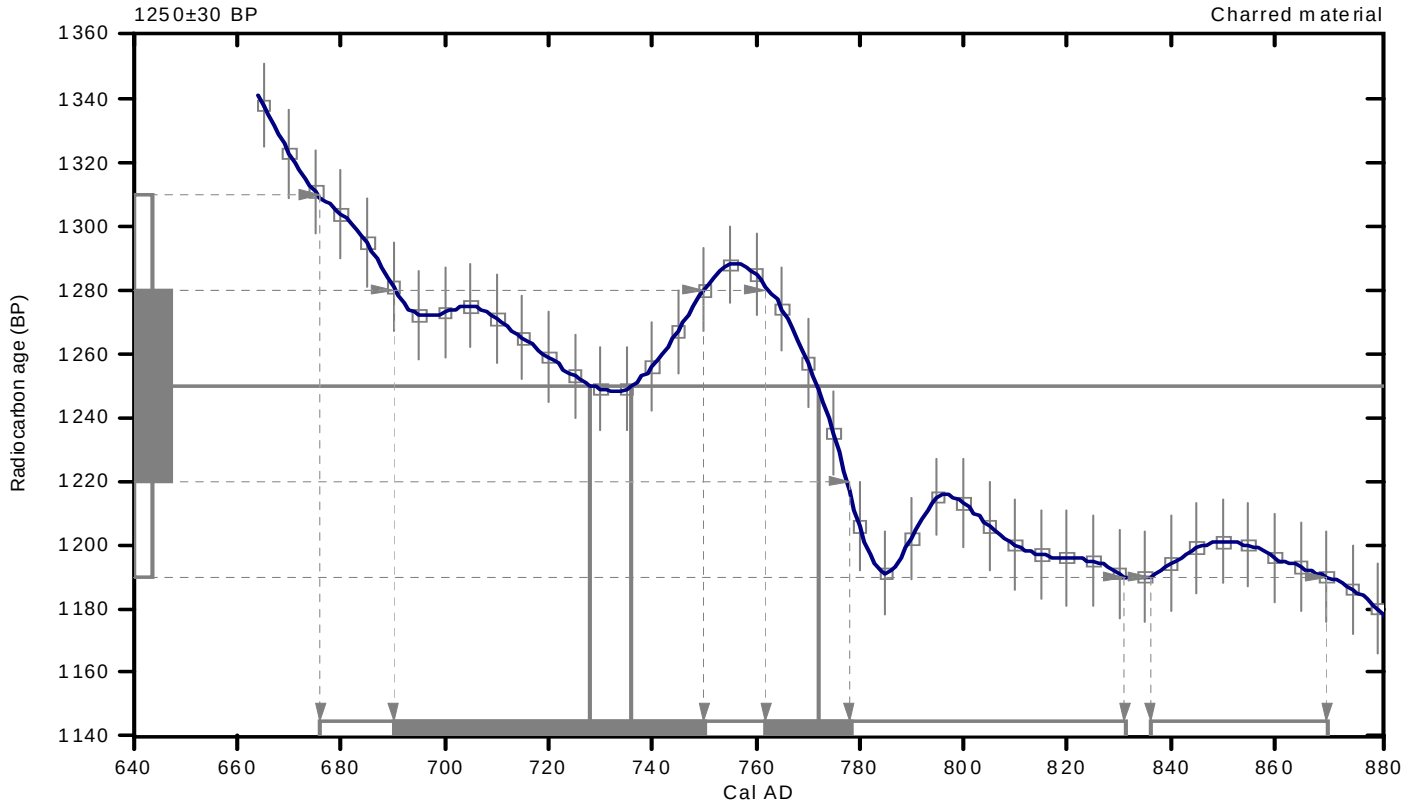
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.5:lab. mult=1)

Laboratory number:	**Beta-330452**
Conventional radiocarbon age:	**1250±30 BP**
2 Sigma calibrated results: **(95% probability)**	**Cal AD 680 to 830 (Cal BP 1270 to 1120) and** **Cal AD 840 to 870 (Cal BP 1110 to 1080)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal AD 730 (Cal BP 1220) and Cal AD 740 (Cal BP 1210) and Cal AD 770 (Cal BP 1180)
1 Sigma calibrated results: (68% probability)	Cal AD 690 to 750 (Cal BP 1260 to 1200) and Cal AD 760 to 780 (Cal BP 1190 to 1170)



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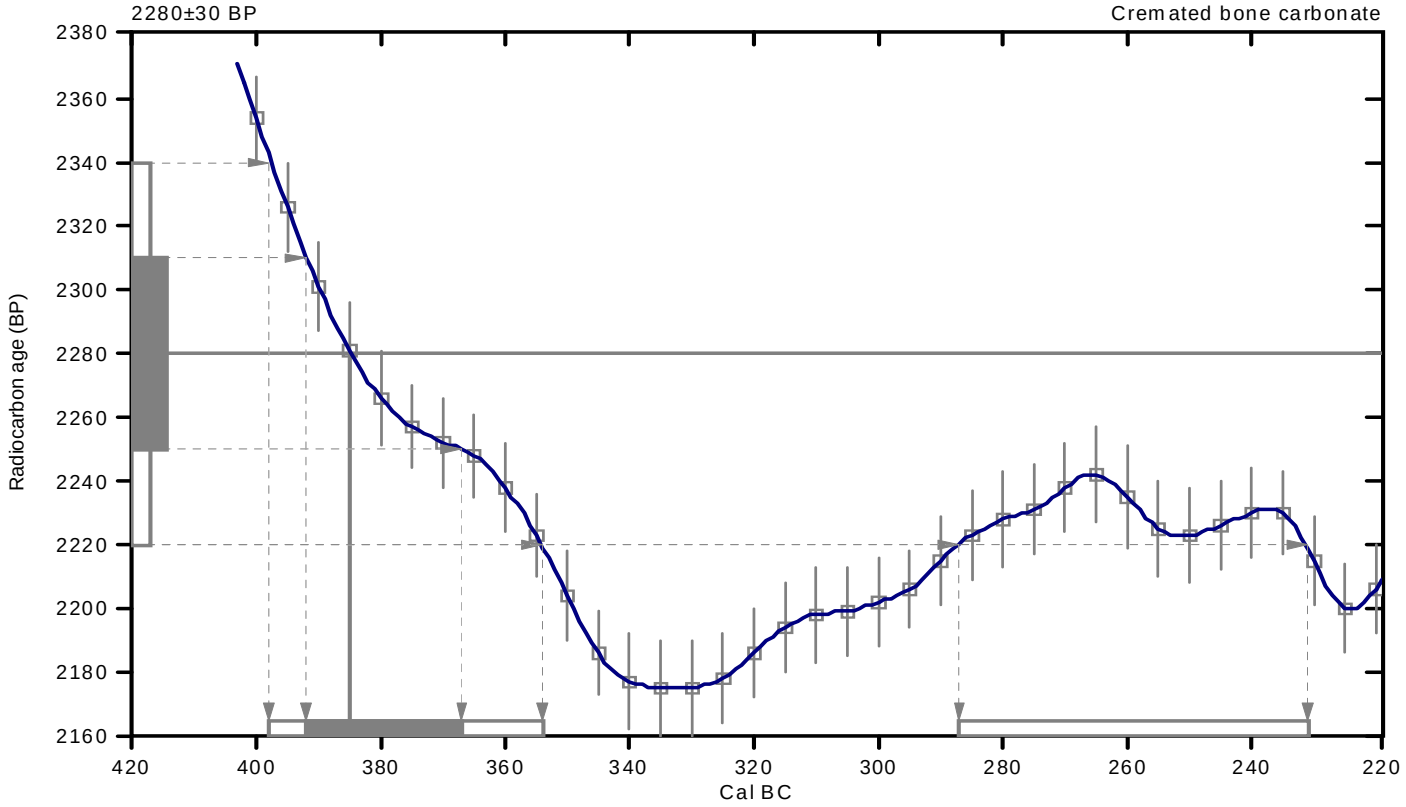
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.4:lab. mult=1)

Laboratory number:	**Beta-330453**
Conventional radiocarbon age:	**2280±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal BC 400 to 350 (Cal BP 2350 to 2300) and Cal BC 290 to 230 (Cal BP 2240 to 2180)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal BC 380 (Cal BP 2340)
1 Sigma calibrated result: (68% probability)	Cal BC 390 to 370 (Cal BP 2340 to 2320)



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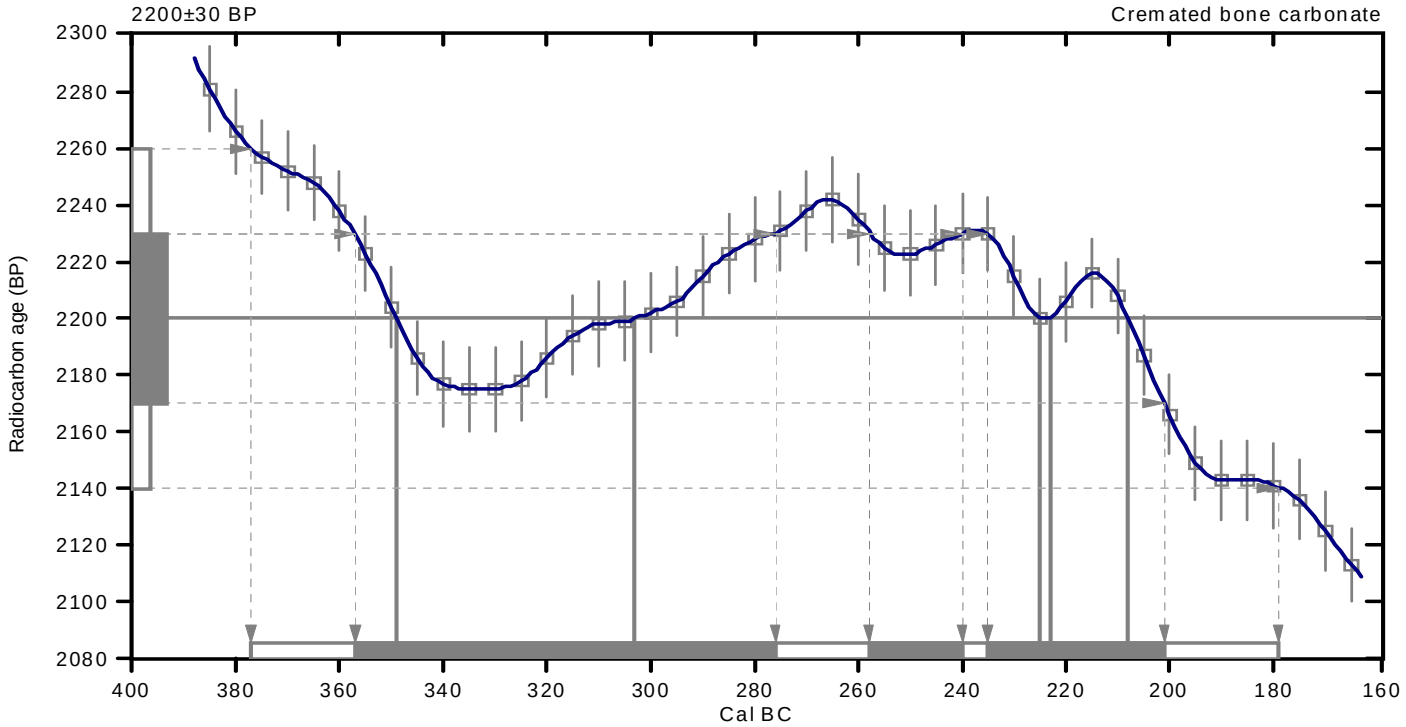
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.6:lab. mult=1)

Laboratory number:	**Beta-330454**
Conventional radiocarbon age:	**2200±30 BP**
2 Sigma calibrated result: (95% probability)	**Cal BC 380 to 180 (Cal BP 2330 to 2130)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal BC 350 (Cal BP 2300) and Cal BC 300 (Cal BP 2250) and Cal BC 220 (Cal BP 2180) and Cal BC 220 (Cal BP 2170) and Cal BC 210 (Cal BP 2160)
1 Sigma calibrated results: (68% probability)	Cal BC 360 to 280 (Cal BP 2310 to 2230) and Cal BC 260 to 240 (Cal BP 2210 to 2190) and Cal BC 240 to 200 (Cal BP 2180 to 2150)



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APPENDIX I

Scientific Signficance Evaluations for Archaeological Sites

December 7, 2012
Report No. 12-1423-0008

Table I.1: Summary of scientific significance ratings for newly recorded or revisited archaeological sites in the LAA

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
GlRj	2	Ø	Ø	P	Ø	Ø	P	P	P	P	P	P?	P	Ø	P	Ø	Ø	Ø	Ø	d	Ø	**H**
	5	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
HaRf	13	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**LEGACY**
	24	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	25	Ø	P	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	P	Ø	Ø	P	Ø	Ø	**L-M**
	26	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	27	Ø	P	Ø	Ø	P	Ø	P	P	P?	Ø	Ø	P	Ø	N	P	Ø	Ø	P	Ø	Ø	**M**
	28	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	29	N	Ø	N	Ø	Ø	Ø	N	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	Ø	d	**L**
	30	N	Ø	N	Ø	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	Ø	d	**L**
	31	N	Ø	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	32	Ø	Ø	P	Ø	Ø	P	P	P	P	P	P?	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**M-H**
	33	Ø	P	Ø	Ø	Ø	P	N	N	N	Ø	P?	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	34	Ø	Ø	P	Ø	Ø	P	P	P	N	Ø	Ø	P	Ø	P	N	Ø	Ø	Ø	d	Ø	**H**
	35	Ø	P	Ø	Ø	Ø	P	N	P	P	Ø	Ø	P	Ø	P	N	Ø	Ø	P	Ø	Ø	**L**
	36	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	37	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed[c]	Integrity: severely disturbed	
	38	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	P?	Ø	Ø	Ø	d	Ø	**L**
	39	N	Ø	Ø	N	Ø	Ø	P	N	N	Ø	Ø	N	Ø	N	P?	Ø	Ø	Ø	d	Ø	**L**
	40	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	P?	Ø	Ø	Ø	d	Ø	**L**
	41	N	Ø	Ø	N	Ø	Ø	P	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
HaRg	3	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	37	N	Ø	Ø	Ø	Ø	P	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	38	Ø	P	Ø	Ø	Ø	P	P	P	N	Ø	Ø	P	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	39	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	40	N	Ø	Ø	N	Ø	Ø	P	P	N	Ø	Ø	P	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	42	N	Ø	Ø	N	Ø	Ø	P	P	N	Ø	Ø	P	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
HaRh	15	N	Ø	Ø	N	Ø	Ø	N	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
HaRj	7	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	P	P	P?	Ø	Ø	P?	Ø	Ø	Ø	**L-M**
	14	Ø	Ø	N	Ø	Ø	P	P?	P	P	Ø	Ø	P	Ø	P	P?	Ø	P	Ø	Ø	Ø	**M-H**
	15	N	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	16[b]	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**L**
	17	N	Ø	N	Ø	Ø	Ø	P	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P?	Ø	Ø	**L**
	18	N	Ø	Ø	NA	NA	NA	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
	19	Ø	Ø	P	Ø	Ø	P	P	P	Ø	Ø	P	P	Ø	P?	P	Ø	P	Ø	Ø	Ø	**M-H**
	21	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	22	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	23	Ø	Ø	P	Ø	Ø	P	P	P	P	Ø	P	P	Ø	P	Ø	Ø	Ø	P	Ø	Ø	**M**
	24[b]	N	Ø	Ø	N	Ø	Ø	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	26	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	27	N	Ø	Ø	N	Ø	Ø	Ø	P	P	Ø	Ø	N	Ø	N	P?	Ø	P	Ø	Ø	Ø	**L-M**
	28	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	29	N	Ø	Ø	N	Ø	Ø	P?	P	Ø	Ø	Ø	Ø	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	30	Ø	P	Ø	Ø	Ø	P	P	P	Ø	Ø	Ø	Ø	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	31	Ø	P	Ø	Ø	Ø	P	Ø	P	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
HaRj	32	Ø	Ø	P	Ø	Ø	P	P	P	P	P	P	P	P?	N	Ø	Ø	P	Ø	Ø	Ø	**M-H**
	33	N	Ø	Ø	N	Ø	Ø	Ø	P	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	34	Ø	Ø	P	Ø	Ø	P	P	P	P?	Ø	Ø	P?	Ø	P?	Ø	Ø	P	Ø	Ø	Ø	**M**
	35	N	Ø	Ø	N	Ø	Ø	Ø	Ø	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
HaRk	1	Ø	Ø	P	Ø	Ø	P	Ø	P	P?	Ø	P?	P?	P?	P?	P	Ø	Ø	P	Ø	Ø	**H**
	2[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	5[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	6	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	N	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	8[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	P	NA	NA	NA	NA	NA	NA	NA	NA	**L**
	12	Ø	Ø	P	Ø	Ø	P	P?	P	P?	Ø	P?	N	Ø	N	Ø	Ø	Ø	P?	Ø	Ø	**L-M**
	13	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	Ø	d	**L**
	15	N	Ø	Ø	Ø	P	Ø	Ø	P	P	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L-M**
	16	N	Ø	Ø	N	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	P?	N	Ø	Ø	Ø	Ø	d	**L**
	17	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	18[a]	NA	NA	NA	NA	NA	NA	NA	P?	P?	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	23	Ø	Ø	P	Ø	Ø	P	P	P	N	P	P?	P	Ø	N	P?	Ø	Ø	P	Ø	Ø	**M-H**
	25[a]	Ø	Ø	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	26[a]	N	Ø	Ø	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	35	Ø	P	Ø	Ø	Ø	P	P?	P?	N	Ø	Ø	P	Ø	P?	Ø	Ø	P	Ø	Ø	Ø	**L-M**
	36[a]	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	38	Ø	Ø	P	Ø	Ø	P	P	P?	N	Ø	P	P	P	P	Ø	Ø	Ø	P	Ø	Ø	**H**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
	43	Ø	P	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	44	N	Ø	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	46	Ø	Ø	P	Ø	Ø	P	P	P	P?	P	P	P	P?	P	P	Ø	Ø	P	Ø	Ø	**H**
HaRk	47	N	Ø	Ø	N	Ø	Ø	Ø	Ø	Ø	Ø	Ø	P	Ø	P	Ø	Ø	Ø	P	Ø	Ø	**L**
	48	N	Ø	Ø	N	Ø	Ø	Ø	Ø	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	49	Ø	Ø	P	Ø	Ø	P	P	P	P?	Ø	P	P	P?	P	Ø	Ø	Ø	P	Ø	Ø	**H**
	50	Ø	Ø	P	Ø	Ø	P	P	P	Ø	Ø	Ø	P	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**M**
	51	N	Ø	Ø	N	Ø	Ø	Ø	N	N	Ø	Ø	Ø	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	52	N	Ø	Ø	N	Ø	Ø	Ø	P	P?	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	53	Ø	P	Ø	Ø	P	Ø	N	N	N	Ø	Ø	Ø	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	54	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	55	Ø	Ø	P	Ø	Ø	P	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L-M**
HaRl	3[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	P	NA	NA	NA	NA	NA	NA	NA	**I**
	4[a]	NA	NA	NA	NA	NA	NA	NA	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	10	NA	NA	NA	NA	NA	NA	P?	P?	Ø	Ø	Ø	Ø	Ø	N	Ø	Ø	Ø	Ø	Ø	d	**L**
	14[b]	N	Ø	Ø	N	Ø	Ø	P?	P	P?	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	**L-M**
	18	N	Ø	Ø	N	Ø	Ø	Ø	Ø	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
	19	N	Ø	Ø	N	Ø	Ø	Ø	Ø	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	20[a]	N	Ø	Ø	N	Ø	Ø	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	P	NA	NA	**I**
	21[a]	N	Ø	Ø	N	Ø	Ø	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	P	NA	NA	**I**
	22[a]	N	Ø	Ø	N	Ø	Ø	NA	NA	NA	NA	NA	P	P	P	NA	NA	NA	NA	NA	NA	**I**
	23[a]	Ø	P	Ø	Ø	Ø	P	NA	P	P?	Ø	NA	NA	NA	NA	NA	NA	NA	P	NA	NA	**I**
	24[a]	N	Ø	Ø	N	Ø	Ø	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	29	N	Ø	Ø	Ø	Ø	P	N	N	N	Ø	Ø	P	Ø	P?	Ø	Ø	Ø	Ø	Ø	d	**L-M**
	30	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	31	N	Ø	Ø	N	Ø	Ø	N	N	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	32	Ø	P	Ø	N	Ø	Ø	N	N	Ø	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	33	N	Ø	Ø	N	Ø	Ø	N	N	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	34[a]	N	Ø	Ø	N	Ø	Ø	N	N	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	35	N	Ø	Ø	N	Ø	Ø	N	N	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	36	N	Ø	Ø	N	Ø	Ø	N	P	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	37	N	Ø	Ø	N	Ø	Ø	N	N	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
HbRf	30[b]	NA	P	NA	NA	NA	NA	N	N	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	d	**LEGACY**
	32[a]	N	NA	NA	NA	NA	NA	NA	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	40[b]	NA	NA	P	NA	P?	NA	P?	P?	P?	NA	P?	NA	NA	NA	P	NA	NA	NA	NA	NA	**M-H**
	42[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	P?	NA	P?	NA	NA	NA	NA	NA	d	NA	**I**
	59	N	Ø	Ø	N	Ø	Ø	N	N	Ø	Ø	Ø	N	Ø	N	N	N	Ø	Ø	Ø	d	**LEGACY**
	60	N	Ø	Ø	N	Ø	Ø	N	N	Ø	Ø	Ø	N	Ø	N	N	N	Ø	Ø	Ø	d	**LEGACY**
	61	Ø	Ø	P	Ø	Ø	P	P	P	P	Ø	P?	N	P?	N	Ø	Ø	Ø	P	Ø	Ø	**M-H**
	62	Ø	Ø	P	Ø	Ø	P	P	P	N	P	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**H**
	63	Ø	Ø	P	Ø	Ø	P	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**M**
	64	Ø	P	Ø	Ø	Ø	P	P	P?	P?	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	Ø	d	**L-M**
	65	Ø	Ø	P	Ø	Ø	P	P?	P	P	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**M**
	66[a]	Ø	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	67	Ø	Ø	P	NA	NA	NA	NA	P	P	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**L**
	82[b]	N	Ø	Ø	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	88	Ø	P	Ø	Ø	Ø	P	N	N	N	Ø	P	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	93	Ø	Ø	P	Ø	Ø	P	P?	P	P	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L-M**
	94	N	Ø	Ø	N	Ø	Ø	P?	P?	P	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**M**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
	95	Ø	P	Ø	Ø	Ø	P	P	P	P?	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L-M**
	96	N	Ø	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	97	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	98	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	99	Ø	P	Ø	Ø	Ø	P	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L-M**
	100	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	102	Ø	P	Ø	N	Ø	Ø	P	P	P?	Ø	P	N	Ø	P?	Ø	Ø	P	Ø	Ø	Ø	**M-H**
	103	Ø	P	Ø	Ø	Ø	P	P	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	104	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	105	N	Ø	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	106	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	107	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	108	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	109	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	PP P	Ø	Ø	**L**
	110	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	111	N	Ø	Ø	N	Ø	Ø	P?	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	Ø	d	**L**
	112	N	Ø	Ø	N	Ø	Ø	P?	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	Ø	d	**L**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
	113	Ø	Ø	P	Ø	Ø	P	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	114	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	115	N	Ø	Ø	Ø	P	Ø	P	P	P	Ø	P?	P?	P	P?	Ø	Ø	Ø	Ø	d	Ø	**M-H**
HbRg	5	Ø	Ø	P	Ø	Ø	P	P	P	P?	P	P	P	P?	P	Ø	Ø	Ø	P	Ø	Ø	**H**
	6	Ø	Ø	P	Ø	Ø	P	P	P	P	Ø	Ø	N	Ø	P?	Ø	Ø	P	Ø	Ø	Ø	**H**
	11	N	Ø	Ø	N	Ø	Ø	Ø	P	Ø	P	Ø	Ø	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L-M**
	15	N	Ø	Ø	N	Ø	Ø	Ø	P	P	Ø	Ø	Ø	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	17	Ø	P	Ø	Ø	P	Ø	N	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	18	N	Ø	Ø	N	Ø	Ø	N	P?	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	46	N	Ø	Ø	Ø	Ø	P	N	P	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	47	Ø	P	Ø	Ø	P	Ø	P	P?	P?	Ø	P	P	Ø	P	Ø	Ø	Ø	Ø	d	Ø	**M-H**
	48	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	49	Ø	Ø	P	Ø	Ø	P	P	P	P?	Ø	P	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**M**
	50	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	P	P	Ø	P	Ø	Ø	Ø	Ø	Ø	d	**L-M**
	51	N	Ø	Ø	N	Ø	Ø	N	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	52	Ø	P	Ø	Ø	P	Ø	P?	P?	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	Ø	d	**L**
	53	N	Ø	Ø	Ø	Ø	P	N	P	P?	Ø	Ø	P	Ø	P	Ø	Ø	Ø	P	Ø	Ø	**L-M**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
	54	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	55	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	P	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	56	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	57	Ø	Ø	P	Ø	Ø	P	N	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	61	Ø	Ø	P	Ø	Ø	P	N	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
HbRh	2	N	Ø	Ø	Ø	Ø	P	P?	P?	N	Ø	Ø	N	Ø	N	Ø	P	Ø	P	Ø	Ø	**M**
	6	Ø	P	Ø	Ø	Ø	P	P	P	P?	Ø	Ø	P?	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**M**
	8	Ø	Ø	P	Ø	Ø	P	P	P	P	Ø	Ø	P?	Ø	P	P	Ø	Ø	Ø	d	Ø	**H**
	10[a]	N	NA	NA	NA	NA	NA	P?	P?	NA	NA	NA	P?	NA	NA	NA	NA	NA	P	NA	NA	**L**
	12	Ø	Ø	P	Ø	Ø	P	P?	P	Ø	Ø	P?	P	Ø	P	Ø	Ø	Ø	Ø	Ø	d	**M-H**
	16	Ø	Ø	P	Ø	Ø	P	P	P	Ø	Ø	P?	P	Ø	Ø	Ø	Ø	Ø	P	Ø	Ø	**H**
	18[a]	Ø	P	Ø	NA	NA	NA	P?	P	NA	P	NA	NA	NA	NA	NA	NA	Ø	P?	Ø	Ø	**L**
	19[a]	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	d	NA	**I**
	20	N	Ø	Ø	N	Ø	Ø	P	P	P	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L-M**
	29[b]	N	Ø	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	32	N	Ø	Ø	N	Ø	Ø	Ø	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	33	Ø	Ø	P	Ø	P	Ø	P?	P	P?	Ø	P	P?	Ø	P?	Ø	Ø	Ø	Ø	d	Ø	**M-H**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
	34	N	Ø	Ø	N	Ø	Ø	N	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	Ø	d	**L**
	36	Ø	Ø	P	Ø	Ø	P	P	P	P	Ø	P	P	P?	P	Ø	Ø	Ø	Ø	d	Ø	**H**
	37	Ø	Ø	P	Ø	Ø	P	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L-M**
	38	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	P?	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	42[a]	NA	NA	NA	NA	NA	NA	P?	P	NA	NA	NA	P?	P?	P?	NA	NA	NA	NA	NA	NA	**L**
	46	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	52	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	53[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	54	Ø	Ø	P	Ø	Ø	P	P?	P	Ø	Ø	Ø	P	Ø	P	Ø	Ø	Ø	P	Ø	Ø	**M-H**
	55	Ø	Ø	P	Ø	Ø	P	P	P	Ø	Ø	Ø	N	Ø	P	Ø	Ø	Ø	Ø	Ø	Ø	**M-H**
	56[b]	NA	NA	P	NA	NA	P	P?	P	NA	NA	NA	NA	P?	NA	NA	NA	NA	NA	NA	NA	**I**
	57	Ø	Ø	P	Ø	Ø	P	N	P	P?	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L-M**
	58[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**I**
	63[a]	N	Ø	NA	NA	NA	Ø	N	N	Ø	Ø	NA	N	Ø	N	NA	NA	NA	NA	NA	NA	**L**
	64[a]	N	Ø	Ø	NA	NA	NA	P?	P	Ø	Ø	NA	N	Ø	N	NA	NA	NA	NA	NA	NA	**L**
	65	Ø	Ø	P	Ø	Ø	P	N	P	N	Ø	Ø	N	Ø	N	P?	Ø	Ø	P	Ø	Ø	**L**
	66	N	Ø	Ø	NA	NA	NA	Ø	Ø	Ø	Ø	Ø	P	P	P	Ø	Ø	P	Ø	Ø	Ø	**H**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
	67	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	68[a]	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	Ø	Ø	P?	Ø	Ø	NA	NA	NA	NA	**L**
	69[a]	N	Ø	Ø	NA	NA	NA	P?	P	P?	Ø	Ø	P?	Ø	P?	NA	NA	Ø	P	Ø	Ø	**L-M**
	104	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	P	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L-M**
	107	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	112	Ø	P	Ø	Ø	Ø	P	P?	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	113	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	P?	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	114	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	115[b]	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	116[b]	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	117[b]	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	120	Ø	P	Ø	Ø	Ø	P	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	121	Ø	Ø	P	Ø	Ø	P	P?	P?	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L-M**
	122	Ø	Ø	P	Ø	Ø	P	P	P	P	P	P	N	Ø	P?	Ø	Ø	P	Ø	Ø	Ø	**M-H**
	123	Ø	Ø	P	Ø	Ø	P	N	N	N	Ø	P	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**M**
	124	N	Ø	Ø	Ø	Ø	P	P?	P	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L-M**
	125	Ø	Ø	P	Ø	Ø	P	P	P	N	Ø	P	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L-M**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
	126	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	127	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	Ø	d	**L**
	128	N	Ø	Ø	N	Ø	Ø	N	P	P	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	129	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	130	Ø	Ø	P	Ø	Ø	P	P	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**M**
	131	Ø	Ø	P	Ø	Ø	P	P	P	N	Ø	P	P	Ø	P	P	Ø	P	Ø	Ø	Ø	**M-H**
	132	Ø	Ø	P	Ø	Ø	P	P	P	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**M**
	133	N	Ø	Ø	Ø	P	Ø	P	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	134	Ø	P	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	135	N	Ø	Ø	Ø	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	136	Ø	Ø	P	Ø	Ø	P	P?	P	P	Ø	Ø	N	Ø	P?	Ø	Ø	P	Ø	Ø	Ø	**M**
	137	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	138	N	Ø	Ø	Ø	P	Ø	P?	P	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	139	N	Ø	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**
	140	Ø	Ø	P	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	d	Ø	**L**
	141	N	Ø	Ø	N	Ø	Ø	N	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	142	N	Ø	Ø	N	Ø	Ø	N	P	N	Ø	Ø	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
	143	N	Ø	Ø	N	Ø	Ø	P	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	144	Ø	Ø	P	Ø	Ø	P	N	P	P?	P	Ø	P?	P?	N	Ø	Ø	Ø	P	Ø	Ø	**M**
	145	Ø	Ø	P	Ø	Ø	P	N	P	P	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**M**
	146	Ø	Ø	P	Ø	Ø	P	P?	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L-M**
	147	Ø	Ø	P	Ø	Ø	P	P?	N	N	Ø	P?	N	Ø	N	Ø	Ø	P	Ø	Ø	Ø	**L-M**
	148	Ø	P	Ø	Ø	Ø	P	N	P	N	Ø	Ø	P	Ø	P	Ø	Ø	P	Ø	Ø	Ø	**L**
HbRi	6	Ø	Ø	P	Ø	Ø	Ø	P	P	P	P	P?	P	P	P	P?	Ø	P	Ø	Ø	Ø	**M-H**
	10	Ø	Ø	P	Ø	Ø	P	P	P	P?	Ø	P	P	P?	P	Ø	Ø	Ø	P	Ø	Ø	**M-H**
	11[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**L**
	12	N	Ø	Ø	Ø	P	Ø	P	N	N	Ø	Ø	P	Ø	P	Ø	Ø	Ø	P	d	Ø	**L**
	24	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	25	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	41	Ø	Ø	P	Ø	Ø	P	P	P	P?	Ø	P?	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**M-H**
	42	Ø	Ø	P	Ø	Ø	Ø	Ø	P?	Ø	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	43	Ø	Ø	P	Ø	Ø	P	P	P	P?	P	P	P	Ø	P?	Ø	Ø	Ø	P	Ø	Ø	**H**
	46	N	Ø	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	50	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**

Borden Unit	Site No.	Scientific Significance Attributes																				Rating
		Artifact frequency: low	Artifact frequency: moderate	Artifact frequency: high	Artifact density: low	Artifact density: moderate	Artifact density: high	Expedient tools	Formed tools	Temporally diagnostic tools	Obsidian for XRF	Intrasite variability	Faunal remains	Cultural features	Material suitable for 14C dating	Suitable for geoarch studies	Burial place	Integrity: intact	Integrity: slightly disturbed	Integrity: moderately disturbed	Integrity: severely disturbed	
	56	N	Ø	Ø	N	Ø	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**
	57	Ø	Ø	P	Ø	Ø	P	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	Ø	ɗ	**L-M**
	58	Ø	Ø	P	Ø	Ø	P	N	P	N	Ø	Ø	P	Ø	P	Ø	Ø	Ø	P	Ø	Ø	**L-M**
	59	N	Ø	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	ɗ	Ø	**L**
	60	N	Ø	Ø	Ø	P	Ø	N	N	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	Ø	Ø	ɗ	**L**
	61	Ø	Ø	P	Ø	Ø	P	P	P	N	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**M**
HbRj	6	N	Ø	Ø	NA	NA	NA	Ø	P	P?	Ø	Ø	N	Ø	N	Ø	Ø	Ø	P	Ø	Ø	**L**

NOTES:
P = Trait has a positive influence on significance rating
P? = Trait potentially present or suspected to be present, positively influencing significance rating
N = Trait absent, negatively influences significance rating
Ø = Trait absent, but neutral influence on significance rating
ɗ = Trait present, negatively influences significance rating
NA = Data not available
L= low; L-M = low-to-moderate; M = moderate; M-H = moderate-to-high; H = high; I = indeterminate; Legacy = legacy site*
* A legacy site is a known archaeological site for which a site form exists in the B.C. Archaeology Branch, but the site is not protected by legislation or no longer exists
a Site not fully investigated due to land access restrictions. In some cases, where adequate data was recored on site forms, a preliminary significance is assessed on the basis of available SFU data
b Site not relocated
Low artifact frequency is defined as 1-10 artifacts recovered
Moderate artifact frequency is defined as 11-25 artifacts recovered
High artifact frequency is defined as more than 25 artifacts recovered
Low artifact density is defined as one artifact recovered per subsurface test
Moderate artifact density is defined as 2-4 artifacts recovered per subsurface test
High artifact density is defined as 5 or more artifacts recovered per subsurface test

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APPENDIX J

Historical Site Descriptions

December 7, 2012
Report No. 12-1423-0008

APPENDIX K

Stakeholder Questionnaires

STAKEHOLDER QUESTIONNAIRE

Background

On behalf of BC Hydro, Golder Associates Ltd. (Golder) is conducting an inventory and assessment of heritage sites in the proposed Site C Clean Energy Project area, located on the Peace River between the city of Fort St. John and the town of Hudson's Hope. This historical study includes the use of a questionnaire to query local and regional historical societies and organizations and individuals regarding historic sites and heritage values in and adjacent to the Project area.

The questionnaire will be used to gather information on what historical resources are valued within and adjacent to the Project area, and why they are important. This information will be integrated into a heritage inventory and assessment report.

Completed questionnaires will not be made public, and your personal or organization name will not be attributed to any specific comments in the report.

We would greatly appreciate a few minutes of your time to complete the attached questionnaire. Please return completed questionnaires to Doris Zibauer, Golder Associates Ltd., at dzibauer@golder.com. Should you have any questions, please contact Doris by email or phone (604-296-4274).

Stakeholder Questionnaire — Historical Study

Site C Clean Energy Project

Name: _____

Date: _____

Organization Name (if applicable):

_____

Location (Town, City):

_____

Phone No: _____

Email: _____

- Historical themes express ideas about movements, events or ideas that have led to the breadth of historic resources visible in a region. Identifying historic themes in a region enables a community to articulate its unique heritage values and identify historic resources based on these values.

Examples of themes may include:

- Influences of the natural environment (natural processes and features, local ecosystems and waterways)
- Inhabiting the land (first inhabitants, migration, immigration, settlement)
- Developing economies (extraction, production, communication, transportation)
- Local government (government institutions, security and law, military and defence)
- Social and community life (community organizations, religious institutions, education and social well-being)
- Local culture (learning and the arts, architecture and design, sports and leisure, philosophy and spirituality)
- Other

What five words or themes would you use to describe the historic identity of the Peace River valley, specifically in and adjacent to the Project area between Fort St. John and Hudson's Hope?

Please rank the words or themes from most important to less important.

a) _____

b) _____

c) _____

d) _____

e) _____

- What types of heritage places or sites (i.e., cabins, homesteads, schools, churches, trails, shipwrecks, etc.) are present in and adjacent to the Project area of the Peace River valley?

Please provide details and specific location if known.

_____

_____

_____

_____

- Based on the types of heritage places or sites identified above, what specific places or sites in and adjacent to the Project area do you think are priorities for further research? Examples of places or sites could include, amongst others, buildings, structures, built heritage features, rural or cultural landscapes, or locations where important events have occurred.

Please rank the top three from most important to less important and identify why these places are priorities.

a) _____

b) _____

c) _____

- Are there any groups or individuals that should be contacted that have knowledge of historic sites and/or historic information in and adjacent to the Project area of the Peace River valley? Please list.

_____
_____
_____
_____

Do you have any other comments about the historical resources in and adjacent to the Project area of the Peace River valley?

_____
_____
_____
_____

Can we contact you by phone if clarification or additional information is required?

☐ Yes ☐ No

Thank you for completing this questionnaire. Your participation is appreciated.

PROPERTY OWNERS / LESSEES INTERVIEW

Introduction

Thank you for taking the time to complete this interview. The purpose of the interview is to invite you to share information about heritage sites located within areas potentially affected by the construction of the proposed Site C Clean Energy Project.

Heritage Impact Assessment Overview

These interviews are being conducted as part of a heritage impact assessment, which is one component of the environmental assessment currently underway. The assessment will identify, record and evaluate the significance of archaeological, historical and palaeontological sites located within the proposed Site C project area; assess potential impacts by the Site C project to these sites; and recommend mitigation options.

The information collected during this interview will be used by the internal BC Hydro Site C project team to identify the potential impacts on heritage sites; make recommendations on avoidance and mitigation measures, and to describe impacts which cannot be avoided or mitigated. Information that may indicate the location of protected heritage sites will not be included in the public versions of documentation related to the project. See the Privacy Statement below for more information.

Project Status

The Site C Clean Energy Project (Site C) is now in Stage 3, the environmental and regulatory review phase, which will include an independent environmental assessment. Stage 3 work includes conducting environmental and engineering field studies in the Peace River valley between the Williston Reservoir and the Alberta border. BC Hydro formally entered the environmental assessment process in May 2011 with the submission of a Project Description Report to the provincial and federal environmental assessment agencies.

Interviewer(s)

One or two members of the Golder Associates Ltd. Heritage Team and a BC Hydro Property Representative.

Privacy Statement

Information shared in the interview will be kept confidential and reported only in aggregate. Information that is shared during the interview on the project's potential physical effects on individual heritage sites will be included in the heritage impact assessment and eventually reported through the Heritage Impact Assessment Report, to the public. Heritage site locations will be redacted or blacked-out from the public version of all documentation related to the project, therefore there is no possibility that identifiable information about the interviewee could be revealed based on a heritage site location.

Information is being collected during this interview to assist with preparation for the environmental and regulatory review phase of the Site C Clean Energy project. Specifically, BC Hydro and its consultants are seeking specific information to help identify heritage sites, potential project effects and areas that may require further follow-up or study. BC Hydro is collecting this information in accordance with various regulatory obligations related to the Site C project such as the BC Environmental Assessment Act, the Canadian Environmental Assessment Act and the BC Heritage Conservation Act. If you have any questions about this information collection, please contact _____, your BC Hydro Property Representative, by phone at _____ or email at: _____.

Interview Questions

1) You have indicated that you have information to share on heritage sites in the project area. The Golder team would like to discuss this/these site(s) with you further. Can you provide more detail regarding this/these sites?

_____

_____

_____

_____

_____

_____

2) If you did not provide permission to view where this/these site(s) are located on your property, could you please show us the location on a map?

_____

_____

_____

_____

3) Do you know of any other heritage sites or locations on the property or in the Project area?

_____

_____

_____

_____

_____

d) Can you provide further details? Or show us the location on a map?

_____

_____

_____

Additional Comments

1) To conclude the interview, do you have any comments that you would like to add?

_____

_____

_____

_____

Please Do Not Identify Yourself or Others in Your Responses

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APPENDIX L

Historical Aerial Photograph Review

December 7, 2012
Report No. 12-1423-0008

Table L.1: Historical Aerial Photograph Review

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1945	Map ID: 141212 Township: 83 Range: 19 Sections: 10, 11, 14, 15, 16, 21, 22, 23, 27, 28, 29, 30, 31, 32, 33	1,3	HbRf-23, HbRf-31, HbRf-37	A8050-70 to 73	**Map Sheet 1:** Agricultural fields, farm houses and lands on the north side of the Peace River, concentrated to one area above terrace. Roads intersect farmland. **Map Sheet 3:** Agricultural fields and lands on the north side of the Peace River, with adjacent roads. Fields are scattered across the landscape.	Sections of agricultural fields and lands above terrace on the north side of the Peace River. Farmland is concentrated to the east of the area, although scattered throughout on the north side of the Peace River. Outside of agricultural areas, the landscape is forested. Small tributaries lead down to the Peace River, intersecting the steep terrace.
1953	Map ID: 141212 Township: 83 Range: 19 Sections: 10, 11, 14, 15, 16, 21, 22, 23, 27, 28, 29, 30, 31, 32, 33	1,3	HbRf-29, HbRf-23, HbRf-31, HbRf-37, HbRf-43	BC1777:43-45	**Map Sheet 1**: Substantial increase in agricultural lands and roadways on the north side of the Peace River. **Map Sheet 3:** Increase in agricultural lands and roadways on the north side of the Peace River. Farmland is becoming more concentrated, but appears to be limited by the steep terrain.	Agricultural fields and lands above terrace on the north side of the Peace River. Farmland is concentrated to the east of the area, although increasing in concentration throughout, on the north side of the Peace River. Outside of agricultural areas, the landscape is forested, however, trees have been removed to establish new agricultural fields. Small tributaries lead down to the Peace River, intersecting the steep terrace.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1954	Map ID: 141212 Township: 83 Range: 19 Sections: 10, 11, 14, 15, 16, 21, 22, 23, 27, 28, 29, 30, 31, 32, 33	1,3	HbRf-23, HbRf-31, HbRf-37	BC1947:91-94 BC1952:56-60	**Map Sheet 1**: Appears same as before (photographic area is limited to mainly the southern shore of the Peace River). **Map Sheet 3:** Appears the same as before.	Concentrated agricultural fields and lands above terrace on the north side of the Peace River. Outside of agricultural areas, the landscape is forested, however, trees have been removed to establish new agricultural fields. Small tributaries lead down to the Peace River, intersecting the steep terrace. The town of Fort St. John, which appears to be largely agriculturally based, can be viewed from a number of these photographs.
1967	Map ID: 141212 Township: 83 Range: 19 Sections: 10, 11, 14, 15, 16, 21, 22, 23, 27, 28, 29, 30, 31, 32, 33	1,3	HbRf-29, HbRf-23, HbRf-31, HbRf-37, HbRf-43	BC5267:249-250; 277-279	**Map Sheet 1**: Concentration of agricultural lands, more built structures and increase in roads. **Map Sheet 3:** Slight increase in agricultural lands, more built structures and increase in roads.	Concentrated agricultural fields and lands above terrace on the north side of the Peace River. Increase in infrastructure, industrial development, and roads. Development (roads) on the south side of the Peace River.
1977	Map ID: 141212 Township: 83 Range: 19 Sections: 10, 11, 14, 15, 16, 21, 22, 23, 27, 28, 29, 30, 31, 32, 33	1,3	HbRf-29, HbRf-23, HbRf-31, HbRf-37, HbRf-43	No. 106-107 A37446 IR (infrared)	**Map Sheet 1**: Concentration of agricultural lands, increase in built structures and roads over the last decade. **Map Sheet 3:** Slight increase in agricultural lands, more built structures and increase in roads.	Concentrated agricultural fields and lands above terrace on the north side of the Peace River. Increase in infrastructure, industrial development, and roads. Also residential housing developments appear closer to Fort St. John. Increased development (roads) on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1981	Map ID: 141212 Township: 83 Range: 19 Sections: 10, 11, 14, 15, 16, 21, 22, 23, 27, 28, 29, 30, 31, 32, 33	1,3	HbRf-29, HbRf-23, HbRf-31, HbRf-37	BC81041 L6-50-53; BC81041:55	**Map Sheet 1**: Appears same as before. **Map Sheet 3:** Appears same as before.	Concentrated agricultural fields and lands above terrace on the north side of the Peace River. Increase in infrastructure, industrial development, and roads. Also residential housing developments appear closer to Fort St. John. Increased development (roads) on the south side of the Peace River.
1986	Map ID: 141212 Township: 83 Range: 19 Sections: 10, 11, 14, 15, 16, 21, 22, 23, 27, 28, 29, 30, 31, 32, 33	1,3	HbRf-29, HbRf-23, HbRf-31, HbRf-37, HbRf-43	BC86047:129-130	**Map Sheet 1:** On the north side of the Peace River, slight decrease in forest coverage due to agriculture, other industry, settlement and increase in roadways. **Map Sheet 3:** On the north side of the Peace River, slight decrease in forest coverage due to agriculture, other industry, settlement and increase in roadways.	Concentrated agricultural fields and lands above terrace on the north side of the Peace River. Small increase in infrastructure, industrial and residential development, and roads. Increasing development (roads and industry) on the south side of the Peace River.
1996	Map ID: 141212 Township: 83 Range: 19 Sections: 10, 11, 14, 15, 16, 21, 22, 23, 27, 28, 29, 30, 31, 32, 33	1,3	HbRf-29, HbRf-23, HbRf-31, HbRf-37, HbRf-43	15BCB96095: 95-96 15BCB96020: 30	**Map Sheet 1:** On the north side of the Peace River, slight increase in development (residential and industrial) and roadways. **Map Sheet 3:** On the north side of the Peace River, slight increase in development (residential and industrial) and roadways.	Concentrated agricultural fields and lands above terrace on the north side of the Peace River. Small increase in infrastructure, industrial and residential development, and roads. Increasing development (roads and industry) on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1997	Map ID: 141212 Township: 83 Range: 19 Sections: 10, 11, 14, 15, 16, 21, 22, 23, 27, 28, 29, 30, 31, 32, 33	1,3	HbRf-29, HbRf-23, HbRf-31, HbRf-37, HbRf-43	30BCC97159: 211-212; 30BCC97159:262-267 (colour)	**Map Sheet 1**: Appears same as before. **Map Sheet 3:** Appears same as before.	Concentrated agricultural fields and lands above terrace on the north side of the Peace River. Infrastructure, industrial and residential development, and roads evident. To a lesser extent, on the south side of the Peace River, there is development (roads and industry).
1945	Map ID: 141227 Township: 84 Range: 21 Sections: 2, 3, 4, 5, 8, 9, 10, 11, 14, 15, 16	5,6,7	HbRh-24, HbRh-35, HbRh-59, HbRh-60, HbRh-61	A8105:21-23; A8105:16-17; A8104:7-11; A8104:99-102; A8105:18-20;	**Map Sheet 5:** Agricultural fields, farm houses and lands along the north side of the Peace River, to the east of Cache Creek. Roads appear to intersect farmland. **Map Sheet 6:** Scattered agricultural fields, farm houses and lands along the north side of the Peace River, to the south and west of Cache Creek. Roads are adjacent to farmland. Historic Sites (Photograph A8105-21): HbRh-24 – A number of structures are visible. One of these may be Bentley's cabin. HbRh-59 – A number of structures are visible. These may be the Freer/Robinson Homestead (1920s – 1940s log structures). HbRh-60 – A number of structures are visible, possibly the Dopp Homestead (1920s-1930s), Bear Flat School (1921) and several log structures.	Agricultural fields, farm houses and lands along the north side of the Peace River, adjacent to Cache Creek. Concentration of agriculture east of Cache Creek. Roads run adjacent to farmland. Forest covers much of the land surrounding the agricultural areas. There is little to no development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
					Map Sheet 7: No development appears on south side of the Peace River. Agricultural fields, farm houses and lands below terrace on the north side of the Peace River. Roads appear to be adjacent to farmland. Historic Site (Photograph A8104-99): HbRh-35 – A number of structures, in two adjacent locations, are visible along the north shore of the Peace River. Possible ford of Peace River. Trail (Photographs A810:19-20): Trail to Ft. Graham and Trail to Hudson's Hope – trails may be visible, but only west of Cache Creek (due to agricultural development)**.**	

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1953	Map ID: 141227 Township: 84 Range: 21 Sections: 2, 3, 4, 5, 8, 9, 10, 11, 14, 15, 16	5,6,7	HbRh-24, HbRh-35, HbRh-59, HbRh-60, HbRh-61	BC1765:85-87; BC1766:9; BC1765:83-84,88	**Map Sheet 5:** Appears same as before. **Map Sheet 6:** Increase in agricultural lands and roadways. Historic Sites (Photograph BC1765:84): HbRh-24 – Difficult to identify as photo is at a small scale. HbRh-59 – Difficult to identify as photo is at a small scale . HbRh-60 – Difficult to identify as photo is at a small scale. **Map Sheet 7:** Appears same as before. Historic Site (Photograph BC1765:88): HbRh-35 – Structures are hardly visible, sediment is accumulating at the location of the site. Possible ford of Peace River.	Agricultural fields, farm houses and lands along the north side of the Peace River, adjacent to Cache Creek. Concentration of agriculture east of Cache Creek, but agriculture is increasing west of Cache Creek. Roads adjacent to farmland. Forest covers much of the land surrounding the agricultural areas, however, more has been cleared for additional agricultural lands. There is little to no development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1954	Map ID: 141227 Township: 84 Range: 21 Sections: 2, 3, 4, 5, 8, 9, 10, 11, 14, 15, 16	5,6,7	HbRh-24, HbRh-35, HbRh-59, HbRh-60, HbRh-61	BC1947:76-79,83-85; BC1952:42-44; BC1941:83-84	**Map Sheet 5:** Appears same as before. **Map Sheet 6:** Appears same as before. Historic Sites (Photograph BC1947:79): HbRh-24 – A number of structures are still visible. One of these may be Bentley's cabin. HbRh-59 – A number of structures are still visible. These may be the Freer/Robinson Homestead (1920s – 1940s log structures) HbRh-60 – A number of structures are still visible. Possibly the Dopp Homestead (1920s-1930s), Bear Flat School (1921) and several log structures. **Map Sheet 7:** Appears same as before. Historic Site (Photograph BC1947:78): HbRh-35 – Structures are no longer visible.	Agricultural fields, farm houses and lands along the north side of the Peace River, adjacent to Cache Creek. Concentration of agriculture east of Cache Creek, but agriculture is increasing west of Cache Creek. Roads adjacent to farmland. Forest covers much of the land surrounding the agricultural areas, however, more has been cleared for additional agricultural lands. There is little to no development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1967	Map ID: 141227 Township: 84 Range: 21 Sections: 2, 3, 4, 5, 8, 9, 10, 11, 14, 15, 16	5,6,7	HbRh-24, HbRh-35, HbRh-59, HbRh-60, HbRh-61	BC5267:180-184; 198-201	**Map Sheet 5:** Major highway (29) is constructed by 1967, across Cache Creek and adjacent to agricultural lands on the north shore of the Peace River. Slightly increasing development (agricultural, industrial etc.). **Map Sheet 6:** Major highway (29) is constructed by 1967, adjacent to agricultural lands on the north shore of the Peace River. Slightly increasing development (agricultural, industrial etc.). Historic Sites (Photograph BC5267:181) HbRh-24 – Fewer structures are visible. A possibility that one of these is Bentley's cabin. HbRh-59 – Fewer structures are visible. A possibility that these may be the Freer/Robinson Homestead (1920s – 1940s log structures). HbRh-60 – A number of structures are still visible. Possibly the Dopp Homestead (1920s-1930s), Bear Flat School (1921) and several log structures. New developments (housing, agriculture, etc.) around location of site.	Agricultural fields, farm houses and lands along the north side of the Peace River, adjacent to Cache Creek. Concentration of agriculture east and west of Cache Creek. Highway 29 built in 1967. Smaller roads run adjacent to farmland. Some forested areas have been cleared for developments (agriculture, housing, etc.). There still appears to be little to no development on the south side of the Peace River (although most photographs focus on the north shore).

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
					Map Sheet 7: Major highway (29) is constructed by 1967, adjacent to agricultural lands on the north shore of the Peace River. Slightly increasing development (agricultural, industrial etc.).	
1977	Map ID: 141227 Township: 84 Range: 21 Sections: 2, 3, 4, 5, 8, 9, 10, 11, 14, 15, 16	5,6,7	HbRh-24, HbRh-35, HbRh-59, HbRh-60, HbRh-61	No. 83-84, 102-104 A37446 IR; No. 84 (infrared)	**Map Sheet 5:** Increase in development (e.g., agricultural lands, roads, gravel extraction) on the north shore of the Peace River. Limited industrial development on the south side of the Peace River. **Map Sheet 6:** Increase in development (e.g., agricultural lands, roads, gravel extraction) on the north shore of the Peace River. Historic Sites (Photograph 102 A37446 IR): HbRh-24 – Appears same as before. HbRh-59 – Appears same as before. HbRh-60 – Appears same as before. **Map Sheet 7:** Increase in development (e.g., agricultural lands, roads, gravel extraction) on the north shore of the Peace River. Limited industrial development on the south side of the Peace River.	Agricultural fields, farm houses and lands along the north side of the Peace River, adjacent to Cache Creek. Concentration of agriculture east and west of Cache Creek. Highway 29 built by 1967. Smaller roads adjacent to farmland. Some forested areas have been cleared for development (agriculture, housing, etc.). There appears to be increasing development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1981	Map ID: 141227 Township: 84 Range: 21 Sections: 2, 3, 4, 5, 8, 9, 10, 11, 14, 15, 16	5,6,7	HbRh-24, HbRh-35, HbRh-59, HbRh-60, HbRh-61	BC81041 L4-68-71; BC81041 L5-60-61,69.	**Map Sheet 5:** Appears same as before. **Map Sheet 6:** Appears same as before. Historic Sites (Photograph BC81041 L4-68): HbRh-24 – Appears same as before. HbRh-59 – Appears same as before. HbRh-60 – Fewer structures are still visible. Possibly the Dopp Homestead (1920s-1930s), Bear Flat School (1921) and several log structures. **Map Sheet 7:** Appears same as before.	Agricultural fields, farm houses and lands along the north side of the Peace River, adjacent to Cache Creek. Concentration of agriculture east and west of Cache Creek. Highway 29 built by 1967. Smaller roads adjacent to farmland. Some forested areas have been cleared for development (agriculture, housing, etc.). There appears to be increasing development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1986	Map ID: 141227 Township: 84 Range: 21 Sections: 2, 3, 4, 5, 8, 9, 10, 11, 14, 15, 16	5,6,7	HbRh-24, HbRh-35, HbRh-59, HbRh-60, HbRh-61	BC86047:127	**Map Sheet 5:** Minor development on the south side of the Peace River (photograph limited to the south side of the Peace River). **Map Sheet 6:** N/A (photograph limited to the south side of the Peace River). **Map Sheet 7:** Appears same as before.	Agricultural fields, farm houses and lands along the north side of the Peace River. There appears to be increasing development on the south side of the Peace River.
1996	Map ID: 141227 Township: 84 Range: 21 Sections: 2, 3, 4, 5, 8, 9, 10, 11, 14, 15, 16	5,6,7	HbRh-24, HbRh-35, HbRh-59, HbRh-60, HbRh-61	15BCB96020: 4-6,25	**Map Sheet 5:** Slight increase in development (e.g., agricultural lands, roadways, buildings, gravel extraction) on the north shore of the Peace River. Also, slightly more industrial development on the south side of the Peace River. **Map Sheet 6:** Slight increase in development (e.g., agricultural lands, roadways, buildings, gravel extraction) on the north shore of the Peace River. Historic Sites (Photograph 15BCB96020:6 [larger *in scale than previous years]*): HbRh-24 – Fewer structures are visible. HbRh-59 – Fewer structures are visible. HbRh-60 – Fewer structures are visible.	Agricultural fields, farm houses and lands along the north side of the Peace River, adjacent to Cache Creek. Concentration of agriculture east and west of Cache Creek. Increasing agricultural, road, and industrial (e.g., gravel extraction) development. There appears to be increasing development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
					Map Sheet 7: Slight increase in development (e.g., agricultural lands, roadways, buildings, gravel extraction)), and in particular, buildings along Hwy 29, on the north shore of the Peace River. Also, slightly more industrial development on the south side of the Peace River.	
1997	Map ID: 141227 Township: 84 Range: 21 Sections: 2, 3, 4, 5, 8, 9, 10, 11, 14, 15, 16	5,6,7	HbRh-24, HbRh-35, HbRh-59, HbRh-60, HbRh-61	30BCC97159: 250; 277-281; 284-288. (colour)	**Map Sheet 5:** Appears same as before. **Map Sheet 6:** Appears same as before. Historic Sites (Photograph 15BCB96020:6): HbRh-24 – Appears same as before. HbRh-59 – Appears same as before. HbRh-60 – Fewer structures are visible. **Map Sheet 7:** Appears same as before.	Agricultural fields, farm houses and lands along the north side of the Peace River, adjacent to Cache Creek. Concentration of agriculture east and west of Cache Creek. Increasing agricultural, road, and industrial (e.g., gravel extraction) development. There appears to be increasing development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1945	Map ID: 141232 Township: 83 Range: 22 Sections: 19, 20, 21, 27, 28, 29, 30, 31, 32, 33, 34, 35	8,9	HbRi-6, HbRi-10	A8104:11-20, 92-98 A8151:12-14; A8294:38-40, 59-67	**Map Sheet 8:** Limited road, infrastructure, and agricultural development on the north side of the Peace River. A road runs east to west and agriculture is concentrated close to the Peace River, on the Attachie Flat terraces. Appears to be a number of structures (possibly a ford) near HbRh-29, along the north shore of the Peace River. **Map Sheet 9:** Limited road, infrastructure, and agricultural development on the north side of the Peace River. A road runs east to west and a bridge crosses the Halfway River. A number of buildings just east of the Halfway River bridge, adjacent to the road. Agriculture is concentrated close to the Peace River, on the Attachie Flat terraces. Trail (Photographs A8104:18-19): Unnamed trail just east of Halfway River and trail to Hudson's Hope – there is little to no indication of the trails on agricultural land, but possible trail(s) within the forested area adjacent to the Halfway River.	Limited road, infrastructure and agricultural development on the north side of the Peace River. A road runs east to west across the steep, terraced, terrain. Much of the area is forested, however, limited by the terrain. No indication of development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1953	Map ID: 141232 Township: 83 Range: 22 Sections: 19, 20, 21, 27, 28, 29, 30, 31, 32, 33, 34, 35	8,9	HbRi-6, HbRi-10	BC1774:75-78	**Map Sheet 8:** Appears same as before *(photographed area limited to the Attachie Flat terraces and south side of Peace River).* **Map Sheet 9:** Increasing agricultural development west of the Halfway River, on the north side of the main roadway.	Increasing road, infrastructure and agricultural development on the north side of the Peace River. A road runs east to west across the steep, terraced, terrain. Forest coverage is limited by agriculture and the terrain. No indication of development on the south side of the Peace River.
1954	Map ID: 141232 Township: 83 Range: 22 Sections: 19, 20, 21, 27, 28, 29, 30, 31, 32, 33, 34, 35	8,9	HbRi-6, HbRi-10	BC1947:68-72; BC1952: 39-41; BC1941:	**Map Sheet 8:** Appears same as before. **Map Sheet 9:** Appears similar to before, with the exception of a number of new buildings just east of the Halfway River bridge, close to the road.	Road, infrastructure and agricultural development on the north side of the Peace River. A road runs east to west across the steep, terraced, terrain. Forest coverage is limited by agriculture and the terrain. Very minimal development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1967	Map ID: 141232 Township: 83 Range: 22 Sections: 19, 20, 21, 27, 28, 29, 30, 31, 32, 33, 34, 35	8,9	HbRi-6, HbRi-10	BC5267:62-65, 117-120	**Map Sheet 8:** Major highway (29) is constructed by 1967, adjacent to agricultural lands on the north shore of the Peace River. Increase in development (i.e., agricultural lands, roadways, buildings), particularly north of Hwy 29. **Map Sheet 9:** Major highway (29) is constructed by 1967, running adjacent to agricultural lands on the north shore of the Peace River. Increase in development (i.e., agricultural lands, roadways, buildings), particularly north of Hwy 29.	Increased road, infrastructure and agricultural development on the north side of the Peace River. Hwy 29, constructed by 1967, runs east to west across the steep, terraced, terrain. Limited, yet slightly increasing industrial development on the south side of the Peace River.
1977	Map ID: 141232 Township: 83 Range: 22 Sections: 19, 20, 21, 27, 28, 29, 30, 31, 32, 33, 34, 35	8,9	HbRi-6, HbRi-10	No. 86 A37445 IR (colour); No. 85-86 A37446 IR (infrared); BC5529: 74-76	**Map Sheet 8:** Increased development, particularly industrial (i.e., power lines, road ways) on the north shore of the Peace River. **Map Sheet 9:** Increased development, particularly industrial (i.e., power lines, road ways) on the north shore of the Peace River.	Increased development, particularly industrial on the north side of the Peace River. Hwy 29, constructed by 1967, runs east to west across the steep, terraced, terrain. Limited development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1981	Map ID: 141232 Township: 83 Range: 22 Sections: 19, 20, 21, 27, 28, 29, 30, 31, 32, 33, 34, 35	8,9	HbRi-6, HbRi-10	BC81041 L3-87-91; BC81041 L4-72; BC81041 L8-75-77.	**Map Sheet 8:** Minimal road development, on/adjacent to the Highway, on the north shore of the Peace River. **Map Sheet 9:** Minimal road and agricultural development on the north shore of the Peace River. Industrial development (ROW clearing, waterway or irrigation ditch) just off of Highway 29. Slight increase in industrial development south of the Peace River.	Slight increase in development (e.g., agricultural, roadways) on the north side of the Peace River. Industrial development (ROW clearing, waterway or irrigation ditch) adjacent to Hwy 29, west of Halfway River. Minimal development on the south side of the Peace River.
1986	Map ID: 141232 Township: 83 Range: 22 Sections: 19, 20, 21, 27, 28, 29, 30, 31, 32, 33, 34, 35	8,9	HbRi-6, HbRi-10	BC86047:123, 125-126.	**Map Sheet 8:** Appears same as before. **Map Sheet 9:** Appears same as before.	Development (e.g., agricultural, roadways, infrastructure) on the north side of the Peace River. Industrial development (ROW clearing, waterway or irrigation ditch) adjacent to Hwy 29, west of Halfway River. Minimal development on the south side of the Peace River.
1996	Map ID: 141232 Township: 83 Range: 22 Sections: 19, 20, 21, 27, 28, 29, 30, 31, 32, 33, 34, 35	8,9	HbRi-6, HbRi-10	15BCB96020: 21-24	**Map Sheet 8:** Slightly increased development (e.g., residential and industrial), particularly adjacent to Highway 29 and on the north shore of the Peace River. **Map Sheet 9:** Slightly increased development (e.g., residential and industrial), particularly adjacent to Highway 29 and on the north shore of the Peace River.	Slightly increased development (e.g., residential and industrial) on the north side of the Peace River. Minimal development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1997	Map ID: 141232 Township: 83 Range: 22 Sections: 19, 20, 21, 27, 28, 29, 30, 31, 32, 33, 34, 35	8,9	HbRi-6, HbRi-10	30BCC97159: 165, 235-239, 241-248 (colour)	**Map Sheet 8:** Appears same as before. **Map Sheet 9:** Appears same as before.	Development (e.g., agricultural, roadways, infrastructure) on the north side of the Peace River. Minimal development on the south side of the Peace River.
1945	Map ID: 141244 Township: 82 Range: 24 Sections: 16,17,18,19,20, 21,22,26,27,28	12,13	HaRj-23, HaRk-10, HaRk-13, HaRk-16, HaRk-29, HaRk-31, HaRk-32, HaRk-34, HaRk-41	A8109:22-24; A8148:66-75; A8149:24-27.	**Map Sheet 12:** Limited road, infrastructure and agricultural development on the north side of the Peace River. A main road runs east to west and agricultural land is scattered across the landscape, just north of this road. Historic Sites (Photograph A8148-71): HbRj-23 – "Moody Homestead" – structures may be visible. HaRk-29 – "Beatty Homestead" – structures appear visible. **Map Sheet 13:** Roads, agricultural lands and associated buildings on the north side of the Peace River. A main road runs east to west and agricultural land is scattered across the landscape, adjacent this road. Farrell Creek runs north to south, and the road crosses over the Creek.	Limited road, infrastructure and agricultural development on the north side of the Peace River. A main road runs east to west, close to the Peace River bank. Aside from agricultural lands much of the area is forested, however, limited by the terrain. No indication of development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
					Historic Sites (Photograph 8149-21): HaRk-10 – “Rutledge’s Cabin – structures appear to be visible. HaRk-13 – Cabin appears to be visible. HaRk-32 – “Forsythe’s Homestead” – structures appear to be visible. HaRk-34 – “Henry Farrell’s Cabin” – cabin may be visible. Trail (Photographs A8149:22-23): Unnamed trail just east of Farrell Creek (heading northwest) – there is a slight indication of the trail through the forested area. Trail (Photographs A8149:19-20): Unnamed trail just west of Farrell Creek (heading north) – there is little to no indication of a trail (possibly due to agricultural lands).	

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1953	Map ID: 141244 Township: 82 Range: 24 Sections: 16,17,18,19,20, 21,22,26,27,28	12,13	HaRj-23, HaRk-10, HaRk-13, HaRk-16, HaRk-29, HaRk-31, HaRk-32, HaRk-34, HaRk-41	BC1774:67-71; BC1769:110	**Map Sheet 12:** Increased agricultural, road and infrastructure development on the north side of the Peace River. Historic Sites (Photograph BC1744:70): HaRj-23 – "Moody Homestead" – structures may still be visible. HaRk-29 – "Beatty Homestead" – structures may be visible **Map Sheet 13:** Increased agricultural, road and infrastructure development on the north side of the Peace River. Farrell Creek runs north to south, and the main road crosses over the Creek. Historic Sites (Photograph BC1774:68 – *smaller scale than 1945 photograph*). HaRk-10 – "Rutledge's Cabin – structures appear to be visible. HaRk-13 – Cabin may still be visible. HaRk-32 – "Forsythe's Homestead" – structures appear to be visible. HaRk-34 – "Henry Farrell's Cabin" – cabin is not identifiable.	Increasing agricultural, road, and infrastructure development on the north side of the Peace River. A main road runs east to west, close to the Peace River bank. Outside of agricultural lands much of the area is forested, however, limited by the terrain. No indication of development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1954	Map ID: 141244 Township: 82 Range: 24 Sections: 16,17,18,19,20, 21,22,26,27,28	12,13	HaRj-23, HaRk-10, HaRk-13, HaRk-16, HaRk-29, HaRk-31, HaRk-32, HaRk-34, HaRk-41	BC1947:55-57, 60-62; BC1952: 20-27.	**Map Sheet 12:** Appears same as before. Historic Sites (Photograph BC1744:70): HaRj-23 – "Moody Homestead" – structure may be visible. HaRk-29 – "Beatty Homestead" – structures may be visible. **Map Sheet 13:** Appears similar to before, with the exception that there is some minor development on the south side of the Peace River. Historic Sites (Photograph BC1952:22 *Different angle than 1953 photograph*): HaRk-13 – Cabin may be visible. HaRk-32 – "Forsythe's Homestead" – structures appear to be visible.	Agricultural, road, and infrastructure development on the north side of the Peace River. A main road runs east to west, close to the Peace River bank. Outside of agricultural lands much of the area is forested, however, limited by the terrain. Minor development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1967	Map ID: 141244 Township: 82 Range: 24 Sections: 16,17,18,19,20, 21,22,26,27,28	12	HaRj-23, HaRk-10, HaRk-13, HaRk-16, HaRk-29, HaRk-31, HaRk-32, HaRk-34, HaRk-41	BC5267:3-5, 117-120.	**Map Sheet 12:** Major highway (29) is constructed by 1967, adjacent to agricultural lands on the north shore of the Peace River. Increase in development (i.e., agricultural lands, roadways, buildings), particularly north of Hwy 29. Historic Sites (Photograph BC5267:5): HaRj-23 – "Moody Homestead" – structure may be visible. HaRk-29 – "Beatty Homestead" – structures may be visible.	Increased road, infrastructure and agricultural development on the north side of the Peace River. Hwy 29, constructed by 1967, runs east to west adjacent to the Peace River bank. Limited, yet slightly increasing industrial development on the south side of the Peace River.
1969	Map ID: 141244 Township: 82 Range: 24 Sections: 16,17,18,19,20, 21,22,26,27,28	13	HaRj-23, HaRk-10, HaRk-13, HaRk-16, HaRk-29, HaRk-31, HaRk-32, HaRk-34, HaRk-41	BC5366:69-70,	**Map Sheet 13:** Major highway (29) is constructed by 1967, adjacent to agricultural lands on the north shore of the Peace River. Increase in development (i.e., agricultural lands, roadways, buildings, industrial), particularly north of Hwy 29. Historic Sites (Photograph BC5366:70 – *scale of photographer is much smaller than previous*): HaRk-13 – Cabin is not identifiable. HaRk-32 – "Forsythe's Homestead" – structures may be visible.	Increased road, infrastructure and agricultural development on the north side of the Peace River. Hwy 29, constructed by 1967, runs east to west adjacent to the Peace River bank. Limited, yet slightly increasing industrial development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1977	Map ID: 141244 Township: 82 Range: 24 Sections: 16,17,18,19,20, 21,22,26,27,28	12,13	HaRj-23, HaRk-10, HaRk-13, HaRk-16, HaRk-29, HaRk-31, HaRk-32, HaRk-34, HaRk-41	No. 91-93 A37446 IR (infrared).	**Map Sheet 12:** Slight increase in development (i.e., roadways, agricultural lands, infrastructure) on the north side of the Peace River. Historic Sites (Photograph 91 A37446 IR): HaRj-23 – "Moody Homestead" – structure is unidentifiable. HaRk-29 – "Beatty Homestead" – structure may be visible. **Map Sheet 13:** Slight increase in development (i.e., roadways, agricultural lands, infrastructure) on the north side of the Peace River. Historic Sites (Photograph 93 A37446 IR): HaRk-32 – "Forsythe's Homestead" – structure may be visible.	Slight increase in road, infrastructure and agricultural development on the north side of the Peace River. Limited development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1981	Map ID: 141244 Township: 82 Range: 24 Sections: 16,17,18,19,20, 21,22,26,27,28	12,13	HaRj-23, HaRk-10, HaRk-13, HaRk-16, HaRk-29, HaRk-31, HaRk-32, HaRk-34, HaRk-41	BC81041 L3-95-97; BC81042 L1-110-111; BC81042 L2-100-105.	**Map Sheet 12:** Appears same as before. Historic Sites (Photograph BC81041 L3-96): HaRj-23 – "Moody Homestead" – structure may be visible. HaRk-29 – "Beatty Homestead" – structure may be visible. **Map Sheet 13:** Slight increase in development (e.g., agricultural and industrial) on the north side of the Peace River. Historic Sites (Photograph BC81042 L1-110): HaRk-32 – "Forsythe's Homestead" – structure is unidentifiable.	Very slight increase in development (e.g., agricultural and industrial) on the north side of the Peace River. Minimal development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1986	Map ID: 141244 Township: 82 Range: 24 Sections: 16,17,18,19,20, 21,22,26,27,28	12,13	HaRj-23, HaRk-10, HaRk-13, HaRk-16, HaRk-29, HaRk-31, HaRk-32, HaRk-34, HaRk-41	BC86047:106	**Map Sheet 12:** Appears same as before. Historic Sites (Photograph BC86047-106 – *scale is much smaller than 1981 photo*): HaRj-23 – "Moody Homestead" – structure is unidentifiable. HaRk-29 – "Beatty Homestead" – structure is unidentifiable. **Map Sheet 13:** Appears same as before.	Development (e.g., agricultural and industrial) on the north side of the Peace River. Minimal development on the south side of the Peace River.
1996	Map ID: 141244 Township: 82 Range: 24 Sections: 16,17,18,19,20, 21,22,26,27,28	12,13	HaRj-23, HaRk-10, HaRk-13, HaRk-16, HaRk-29, HaRk-31, HaRk-32, HaRk-34, HaRk-41	15BCB96020:?	**Map Sheet 12:** Slight increase in development (i.e., industrial, agricultural) on the north side of the Peace River. Historic Sites: HaRj-23 – "Moody Homestead" – structure is unidentifiable. HaRk-29 – "Beatty Homestead" – structure is unidentifiable. **Map Sheet 13:** Slight increase in development (i.e., industrial, agricultural) on the north side of the Peace River.	Slightly increased development (e.g., industrial and agricultural) on the north side of the Peace River. Minimal development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1997	Map ID: 141244 Township: 82 Range: 24 Sections: 16,17,18,19,20, 21,22,26,27,28	12,13	HaRj-23, HaRk-10, HaRk-13, HaRk-16, HaRk-29, HaRk-31, HaRk-32, HaRk-34, HaRk-41	30BCC97159: 55-61 (colour)	**Map Sheet 12:** Appears same as before. Historic Sites (Photograph 30BCC97159:57): HaRj-23 – "Moody Homestead" – structure may be visible. HaRk-29 – "Beatty Homestead" – structures may be visible. **Map Sheet 13:** No1997 photographs of entire map sheet are. Likely appears the same as before.	Development (e.g., industrial and agricultural) on the north side of the Peace River. Minimal development on the south side of the Peace River.
1945	Map ID: 141253 Township: 82 Range: 25 Sections: 2,3,10,11,14,15	14	HaRk-9, HaRk-33	A8150:45-47	Limited road, infrastructure and agricultural development on the north side of the Peace River. A main road runs east to west, close to the Peace River bank. Historic Sites (Photograph A8150-45): HaRk-9 – a cabin and a possible corral - structure is unidentifiable. HaRk-33 – "Robinson Homestead" – structure is unidentifiable. Trail (Photographs A8150:45-46): Trail to Hudson's Hope is likely covered by the road on the north side of the Peace River.	Limited road, infrastructure and agricultural development on the north side of the Peace River. A main road runs east to west, close to the Peace River bank. Outside of agricultural lands much of the area is forested, however, limited by the terrain. No indication of development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1953	Map ID: 141253 Township: 82 Range: 25 Sections: 2,3,10,11,14,15	14	HaRk-9, HaRk-33	BC1769:107-109; BC1774:65-66	Increase in road, infrastructure and agricultural development on the north side of the Peace River. A main road runs east to west, close to the Peace River bank. Historic Sites (Photograph A8150-45): HaRk-9 – a cabin and a possible corral – structures may be visible. HaRk-33 – "Robinson Homestead" – structures may be visible.	Increasing agricultural, road, and infrastructure development on the north side of the Peace River. A main road runs east to west, close to the Peace River bank. Outside of agricultural lands much of the area is forested, however, limited by the terrain. No indication of development on the south side of the Peace River.
1954	Map ID: 141253 Township: 82 Range: 25 Sections: 2,3,10,11,14,15	14	HaRk-9, HaRk-33	BC1947: 51-54,58; BC1952: 16-19	Appears same as before on the north side of the Peace River bank. There is the start of some minor development on the south shore. Historic Sites (*photographs are shot from a different angle than 1953, sites are not visible*).	Agricultural, road, and infrastructure development on the north side of the Peace River. A main road runs east to west, close to the Peace River bank. Outside of agricultural lands much of the area is forested, however, limited by the terrain. Some minor development on the south side of the Peace River.
1969	Map ID: 141253 Township: 82 Range: 25 Sections: 2,3,10,11,14,15	14	HaRk-9, HaRk-33	BC5366:71.	Increase in residential, agricultural, road and industrial development on the north side of the Peace River, particularly just east of Lynx Creek. Highway 29, which runs east to west along the Peace River bank, was built by1967.	Increase in residential, road, agricultural and industrial development on the north side of the Peace River. Hwy 29, constructed by 1967, runs east to west adjacent to the Peace River bank. Limited, yet slightly increasing industrial development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1977	Map ID: 141253 Township: 82 Range: 25 Sections: 2,3,10,11,14,15	14	HaRk-9, HaRk-33	No. 94-95 A37446 IR (infrared)	Increase in residential, road, agricultural and industrial development on the north side of the Peace River, particularly adjacent to Lynx Creek.	Increase in residential, road, agricultural and industrial development on the north side of the Peace River. Limited development on the south side of the Peace River.
1981	Map ID: 141253 Township: 82 Range: 25 Sections: 2,3,10,11,14,15	14	HaRk-9, HaRk-33	BC81042 L1-112	Slight increase in residential, road, agricultural and industrial development on the north side of the Peace River.	Slight increase in residential, road, agricultural and industrial development on the north side of the Peace River. Limited development on the south side of the Peace River.
1996	Map ID: 141253 Township: 82 Range: 25 Sections: 2,3,10,11,14,15	14	HaRk-9, HaRk-33	15BCB96020:?	Substantial increase in residential, road, agricultural and industrial development on the north side of the Peace River, particularly closer to Hudson's Hope.	Substantial increase in residential, road, agricultural and industrial development on the north side of the Peace River. Limited development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1945	Map ID: 141252 Township: 81 Range: 25 Sections: 18,19	15	HaRl-5, HaRl-22	A8145:72-76	Limited road, infrastructure and agricultural development on the north side of the Peace River. A main road runs east to west, adjacent to the Peace River. Historic Sites (Photograph A8145-74): HaRl-5 – not visible. HaRl–22 – not visible. Trail (Photographs A8145:72-73): Indication of the Rocky Mountain Portage trail from Hudson's Hope, particularly through the forested area north of the main road.	Limited road, infrastructure and agricultural development on the north side of the Peace River. A road runs east to west, adjacent to the Peace River. Much of the area is forested, however, limited by the terrain. Very minimal industrial development on the south side of the Peace River.
1953	Map ID: 141252 Township: 81 Range: 25 Sections: 18,19	15	HaRl-5, HaRl-22	BC1769:104-106	Increase in residential, road and agricultural development on the north side of the Peace River. A main road runs east to west, adjacent to the Peace River.	Increase in residential, road and agricultural development on the north side of the Peace River. A road runs east to west, adjacent to the Peace River. Much of the area is forested, however, limited by the terrain. Very minimal industrial development on the south side of the Peace River.
1954	Map ID: 141252 Township: 81 Range: 25 Sections: 18,19	15	HaRl-5, HaRl-22	BC1947: 47-50; BC1952: 12-15	Appears same as before.	Residential, road and agricultural development on the north side of the Peace River. A road runs east to west, adjacent to the Peace River. Much of the area is forested, however, limited by the terrain. Very minimal industrial development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1969	Map ID: 141252 Township: 81 Range: 25 Sections: 18,19	15	HaRl-5, HaRl-22	BC5366: 72-73;106-107	Substantial increase in residential, road and agricultural development on the north side of the Peace River, particularly within the vicinity of Hudson's Hope. Highway 29, which runs east to west along the Peace River bank, was built by1967. With the opening of the W.A.C. Bennett Dam in 1968, just 19 km west of Hudson's Hope, there is increased development on the south side of the Peace River.	Substantial increase in residential, road, infrastructure and agricultural development on the north side of the Peace River. Hwy 29, constructed by 1967, runs east to west, adjacent to the Peace River. Increase in industrial development on the south side of the Peace River.
1977	Map ID: 141252 Township: 81 Range: 25 Sections: 18,19	15	HaRl-5, HaRl-22	No. 97-98 A37445 IR (colour);	Increase in residential, road and industrial development on the north side of the Peace River, particularly within the vicinity of Hudson's Hope. Highway 29, which runs east to west along the Peace River bank, was built by1967.	Increase in residential, road and industrial development on the north side of the Peace River. Hwy 29, constructed by 1967, runs east to west, adjacent to the Peace River. Increase in industrial development on the south side of the Peace River.

Year	Township / Range / Section	Map Sheets	Recorded Sites	Aerial Photographs	Project Area Description	Surrounding Area
1981	Map ID: 141252 Township: 81 Range: 25 Sections: 18,19	15	HaRl-5, HaRl-22	BC81042 L1-115-117	On the north side of the Peace River, there is an increase in development, particularly residential and associated community infrastructure, as the community of Hudson's Hope grows.	Increase in residential, road and industrial development on the north side of the Peace River, particularly within and adjacent to Hudson's Hope. Increase in industrial development on the south side of the Peace River.
1996	Map ID: 141252 Township: 81 Range: 25 Sections: 18,19	15	HaRl-5, HaRl-22	15BCB96020:?	On the north side of the Peace River, there continues to be an increase in development, including residential, associated community infrastructure and industrial, as the community of Hudson Hope grows.	Increase in residential, road and industrial development on the north side of the Peace River, particularly within and adjacent to Hudson's Hope. Increase in industrial development on the south side of the Peace River.

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APPENDIX M

Site Specific E-PAST Results

Appendix M-1 – Archaeology

Appendix M-2 – Historical

December 7, 2012
Report No. 12-1423-0008

APPENDIX M-1
Site Specific E-PAST Results – Archaeology

APPENDIX M-1
Site Specific E-PAST Results
Archaeology

Site	Fetch Length (km)	Elevation of Site (m.amsl)	Exposure	Terrain Composition	Slope	Access	Score	Rating	Comments
'HbRf-61'	7.8	466	86	> 25°	> 25°	known or apparent access	26	MODERATE	-upper terrace at slope break, just downstream of the Moberly River outlet
'HbRg-53'	6.1	461	305	Loose Sands, Silts, Topsoil	> 25°	known or apparent access	58	HIGH	-mid terrace on narrow bench between upper terrace and active erosive face
'HbRg-6'	4.7	462	287	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	46	HIGH	- site 40m from active eroding stream (terrace bank) and at Probable maximum flood elevation - site at slope break btw terrace and gully just below Probable maximum flood elevation - went with higher slope range
'HbRg-5'	4.7	462	287	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	46	HIGH	- site at slope break of mid-terrace and active eroding bank of P.River
'HbRg-18'	4.6	463	287	Loose Sands, Silts, Topsoil	5° to 25°	potential access	41	HIGH	- same as above (HbRg-5) - lowest relict terrace remains in P.River below
'HbRg-11'	6	470	90	Loose Sands, Silts, Topsoil	> 25°	known or apparent access	26	MODERATE	- same as above (HbRg-18) - sign: fluvial deposit with relict P.River channel below
'HbRh-37'	2.1	460	204	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	46	HIGH	- at side of HWY 29, middle of mid-terrace - shorter fetch, same high erosion rating as aspect 204°
'HbRh-34'	10.2	453	253	Loose Sands, Silts, Topsoil	5° to 25°	potential access	41	HIGH	- just upslope from mid/low terrace break - at edge of limestone deposit? (open pit area)
'HaRk-23'	7.75	448	260	Loose Sands, Silts, Topsoil	< 5°	potential access	29	MODERATE	- relict fluvial terrace (lower) - similar elevation to present P.River level
'HbRh-6'	8	462	257	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	58	HIGH	- mid-terrace at slope break to lower Ferrell - tracks visible on GE from vehicles
'HbRh-36'	3.5	460	240	Loose Sands, Silts, Topsoil	< 5°	known or apparent access	46	HIGH	- spans HWY 29 near Bear Flat limestone pit (?) - mid-terrace
'HbRi-43'	9.3	457	231	Loose Sands, Silts, Topsoil	< 5°	known or apparent access	42	HIGH	- lower terrace - near Attacline
'HaRj-28'	6	449	245	Loose Sands, Silts, Topsoil	5° to 25°	low access	36	MODERATE	- lower terrace right side P.River - vegetated/forested
'HaRj-14'	5.9	460	238	Loose Sands, Silts, Topsoil	> 25°	low access	64	HIGH	- on vegetated bank of the P.River just below Probable maximum flood level
'HaRj-19'	5.4	456	238	Loose Sands, Silts, Topsoil	> 25°	low access	48	HIGH	- same as above (HaRj-14)
'HaRk-35'	6.5	462	260	Loose Sands, Silts, Topsoil	5° to 25°	potential access	53	HIGH	- same as above (HaRj-14)
'HaRk-38'	6.35	462	260	Loose Sands, Silts, Topsoil	> 25°	potential access	69	HIGH	- same as above (HaRj-14)
'HbRg-17'	6.5	459	225	Loose Sands, Silts, Topsoil	< 5°	low access	32	MODERATE	- mid-terrace just beyond slope break to eroded left bank of P.R.
'HbRh-113'	8	462	257	Loose Sands, Silts, Topsoil	5° to 25°	potential access	53	HIGH	- at slope break on mid-terrace

Site Specific E-PAST Results
Archaeology

Site	Fetch Length (km)	Elevation of Site (m.amsl)	Exposure	Terrain Composition	Slope	Access	Score	Rating	Comments
'HbRh-65'	10	463	252	Loose Sands, Silts, Topsoil	< 5°	potential access	37	MODERATE	- mid-terrace
'HbRh-120'	2.7	445	215	Loose Sands, Silts, Topsoil	> 25°	low access	16	LOW	- at slope break of mid & lower terrace
'HbRh-121'	4	448	213	Loose Sands, Silts, Topsoil	< 5°	low access	0	LOW	- mid terrace - vegetated
'HbRh-124'	3.5	456	211	Loose Sands, Silts, Topsoil	5° to 25°	low access	24	LOW	- at slope break of mid & lower terrace
'HbRh-16'	5.3	470	217	Loose Sands, Silts, Topsoil	5° to 25°	potential access	53	HIGH	- upper terrace at edge of gully (creek)
'HbRi-41'	1	465	350	Loose Sands, Silts, Topsoil	> 25°	potential access	5	LOW	- NW aspect on right bank of Halway River - 2.7km upstream from outlet
'HaRj-22'	6.5	459	248	Loose Sands, Silts, Topsoil	< 5°	low access	32	MODERATE	- vegetated lower terrace right bank P.R.
'HaRl-10'	13.3	462	225	Loose Sands, Silts, Topsoil	5° to 25°	potential access	53	HIGH	- at bottom of slope of middle terrace - in flowslide - at edge of HWY 29 - right bank of Lynx Ck 70m from present channel - lower terrace undulating terrain
'HbRh-29'	9.8	436	265	Loose Sands, Silts, Topsoil	< 5°	low access	0	LOW	- same as HbRh-32
'HbRh-20'	10.5	466	110	Loose Sands, Silts, Topsoil	< 5°	potential access	21	LOW	- on mid terrace at toe of historical flow slide - 30m from slope to lower terrrace
'HbRh-61'	9.8	461	265	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	58	HIGH	- rural residence on mid-terrace at base of slope to upper terrace
'HbRf-42'	2.7	416	296	Loose Sands, Silts, Topsoil	5° to 25°	low access	0	LOW	- lower terrace on vegetated bank of current P.River
'HaRj-24'	6.5	459	248	Loose Sands, Silts, Topsoil	< 5°	low access	32	MODERATE	- same as HaRj-22
'HaRl-23'	4.1	461	235	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	58	HIGH	- right bank P.R. at known access point
'HbRh-107'	3.5	460	203	Loose Sands, Silts, Topsoil	5° to 25°	low access	36	MODERATE	- on vegetated slope btw upper & mid terrace
'HbRg-48'	8.5	458	306	Loose Sands, Silts, Topsoil	5° to 25°	low access	36	MODERATE	- lower terrace at slope break to left bank P.R.
'HbRg-56'	7	446	306	Loose Sands, Silts, Topsoil	5° to 25°	low access	18	LOW	- at slope break of lower terrace and left bank P.R. - narrow shelf
'HbRg-57'	6.3	457	305	Loose Sands, Silts, Topsoil	> 25°	low access	48	HIGH	- same as above (HbRg-57)
'HbRi-56'	7.1	461	225	Loose Sands, Silts, Topsoil	5° to 25°	potential access	53	HIGH	- left bank P.R.
'HbRi-58'	11.6	457	236	Loose Sands, Silts, Topsoil	5° to 25°	potential access	53	HIGH	- on a knoll on the left bank Halfway R - 1 km upslope from outlet
'HaRk-46'	7.7	449	260	Loose Sands, Silts, Topsoil	< 5°	low access	24	LOW	-on relict lower fluvial deposition

Site Specific E-PAST Results
Archaeology

Site	Fetch Length (km)	Elevation of Site (m.amsl)	Exposure	Terrain Composition	Slope	Access	Score	Rating	Comments
'HaRj-27'	5.7	458	236	Loose Sands, Silts, Topsoil	5° to 25°	low access	48	HIGH	- at slope break of mid-terrace & bank of P.River
'HbRh-133'	4.4	462	225	Loose Sands, Silts, Topsoil	5° to 25°	potential access	53	HIGH	- mid-terrace forrested slope - at edge of Watson Rd
'HbRh-126'	2.8	452	203	Organics	< 5°	low access	24	LOW	- mid-terrace depressional area - adjacent HWY 29
'HbRh-134'	2.2	457	203	Organics	< 5°	low access	36	MODERATE	- same as above (HbRh-126)
'HbRh-139'	4.4	438	235	Loose Sands, Silts, Topsoil	> 25°	low access	32	MODERATE	- at top of slope break from mid to lower terrace
'HaRk-10'	5	470	237	Loose Sands, Silts, Topsoil	< 5°	low access	32	MODERATE	- at bottom of slope break btw mid & lower terrace
'HbRh-53'	3.3	450	206	Organics	< 5°	low access	24	LOW	- mid terrace depressional area - near Jct of HWY 29 & Watson Rd
'HaRk-5'	5	464	197	Loose Sands, Silts, Topsoil	5° to 25°	low access	48	HIGH	- at base of Peace River Valley walls to upper plateau - adj Hwy 29
'HbRh-45'	3.7	424	315	Loose Sands, Silts, Topsoil	5° to 25°	low access	0	LOW	- on right bank of P.Riiver on vegetated lower terrace
'HbRh-35'	7.4	434	262	Loose Sands, Silts, Topsoil	5° to 25°	potential access	5	LOW	- left bank P.River just upslope from active flood plain
'HbRi-10'	11.3	442	237	Loose Sands, Silts, Topsoil	< 5°	potential access	21	LOW	- left bank Farrell Ck, 1km upstream from outlet
'HbRh-66'	1.8	453	180	Organics	< 5°	low access	9	LOW	- depressional area mid terrace
'HbRh-46'	1.8	445	185	Loose Sands, Silts, Topsoil	< 5°	low access	0	LOW	-mid terrace adjacent hwy 29
'HaRk-44'	6.9	463	258	Loose Sands, Silts, Topsoil	> 25°	low access	64	HIGH	- on talus slope btw mid & lower terrace
'HbRh-67'	8	457	252	Loose Sands, Silts, Topsoil	< 5°	potential access	37	MODERATE	- same as HbRh-56
'HbRh-32'	10.3	432	265	Loose Sands, Silts, Topsoil	< 5°	low access	0	LOW	- lower terrace <100m from present river level - 450m to mid terrace - at edge of hay fields
'HbRj-6'	12	460	230	Loose Sands, Silts, Topsoil	> 25°	low access	64	HIGH	- within gully feature in upper terrace - 150m from present P.River flow
'HbRh-38'	11	450	250	Organics	< 5°	potential access	53	HIGH	- on middle terrace in depression - long fetch of ~11km as Bear Flat to the SW will be submerged - 400m to lower terrrace - 330m to upper terrace
'HbRf-62'	5	436	105	Loose Sands, Silts, Topsoil	5° to 25°	low access	0	LOW	- mid-terrace on concave slope between plateau & P.River
'HbRh-7'	12.1	467	250	Loose Sands, Silts, Topsoil	< 5°	potential access	37	MODERATE	- mid terrace, 100m from talus slope - <200m from present flow in P.River
'HbRh-19'	8	460	225	Loose Sands, Silts, Topsoil	5° to 25°	potential access	53	HIGH	- at slope break btw upper & (low) mid terrace
'HbRj-10'	20.2	440	250	Loose Sands, Silts, Topsoil	< 5°	low access	24	LOW	- right bank Peace River vegetated lower terrace

Site	Fetch Length (km)	Elevation of Site (m.amsl)	Exposure	Terrain Composition	Slope	Access	Score	Rating	Comments
'HbRh-8'	8.9	466	258	Loose Sands, Silts, Topsoil	> 25°	potential access	69	HIGH	- 1.5km strip ~40m wide at edge of mid terrace - slope break to lower terrace
'HaRk-45'	1.4	467	185	Loose Sands, Silts, Topsoil	< 5°	potential access	21	LOW	- terrace adjacent to Hwy 29
'HbRg-50'	1.35	465	179	Loose Sands, Silts, Topsoil	< 5°	low access	12	LOW	- mid terrace at head of minor gully feature
'HbRh-115'	7.3	458	256	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	58	HIGH	- at slope break on mid terrace with lower terrace - residence nearby
'HbRh-137'	3	468	217	Loose Sands, Silts, Topsoil	5° to 25°	potential access	41	HIGH	- on vegetated slope btw upper and mid terrace
'HbRh-142'	1.9	432	311	Loose Sands, Silts, Topsoil	> 25°	low access	0	LOW	- on vegetated right P.River at toe of terrace
'HaRk-49'	2.4	462	180	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	37	MODERATE	- private residence on lower terrace, adjacent Hwy 29
'HbRg-28'	6.3	473	305	Loose Sands, Silts, Topsoil	5° to 25°	potential access	41	HIGH	- at slope break btw mid & upper terrace
'HbRh-56'	8	459	252	Loose Sands, Silts, Topsoil	< 5°	potential access	37	MODERATE	- Bear Flat, middle terrace - adjacent hwy, numerous trails observed on GE in area - at edge of hay field - 350m from upper terrace - 150m from lower terrace
'HaRk-12'	5	470	250	Loose Sands, Silts, Topsoil	5° to 25°	potential access	53	HIGH	- middle terrace - outlet of Farrel Ck right bank - peninsula of land ~480m elevation formed by erosion from Farrell Ck relict channels and Peace River in glaciofluvial seds - 100m from active erosion face
'HbRi-11'	14.3	440	236	Loose Sands, Silts, Topsoil	< 5°	low access	16	LOW	- lower terrace at Attachie - GE image low reso (reviewed 2006 air photo) - on the banks of the P.River in a back channel
'HbRi-12'	14.3	442	236	Loose Sands, Silts, Topsoil	< 5°	low access	16	LOW	- lower terrace just upstream of confluence with Halfway River
'HaRl-3'	1.3	470	245	Loose Sands, Silts, Topsoil	> 25°	potential access	37	MODERATE	- 4km downstream from Peace canyon dam, left side current bank of P.River
'HaRl-7'	11.3	465	46	Loose Sands, Silts, Topsoil	5° to 25°	low access	12	LOW	- at shore of treed island within the P.River - erosion tool scope of L may be too low - wave scour
'HbRh-18'	6.5	470	225	Loose Sands, Silts, Topsoil	5° to 25°	potential access	53	HIGH	- at slope break btw upper & mid terrace
'HaRk-25'	2.1	466	180	Loose Sands, Silts, Topsoil	5° to 25°	potential access	32	MODERATE	- adj Hwy 29 on lower terrace
'HbRg-55'	6.3	454	305	Loose Sands, Silts, Topsoil	> 25°	potential access	41	HIGH	- on narrow bench on mid terrace - talus slopes below & above

Site Specific E-PAST Results
Archaeology

Site	Fetch Length (km)	Elevation of Site (m.amsl)	Exposure	Terrain Composition	Slope	Access	Score	Rating	Comments
'HbRi-57'	13	454	235	Loose Sands, Silts, Topsoil	< 5°	known or apparent access	34	MODERATE	- Attachie near road on terrace
'HbRh-123'	2.8	454	185	Loose Sands, Silts, Topsoil	5° to 25°	low access	24	LOW	- at slope break btw mid and upper terrace - at edge of upper Bear Flat
'HbRh-125'	2.3	456	177	Loose Sands, Silts, Topsoil	< 5°	potential access	17	LOW	- roadside Hwy 29 - upper terrace - Bear Flat
'HbRh-131'	7.5	448	253	Loose Sands, Silts, Topsoil	> 25°	low access	48	HIGH	- at slope break mid-lower on mid
'HbRh-58'	7.8	464	245	Loose Sands, Silts, Topsoil	< 5°	potential access	37	MODERATE	- on mid terrace within 50m from terrace step
'HbRh-104'	5	454	217	Loose Sands, Silts, Topsoil	> 25°	potential access	53	HIGH	- at slope break of mid-low lower terrace - Bear Flat - roadside of hwy 29
'HaRl-18'	1.9	456	193	Loose Sands, Silts, Topsoil	> 25°	low access	16	LOW	- left bank P.River just up from active FP
'HaRl-29'	10.4	455	225	Loose Sands, Silts, Topsoil	5° to 25°	potential access	41	HIGH	- at Lynx Ck - lower terrace - trailer park? (field)
'HbRi-50'	1.3	459	180	Loose Sands, Silts, Topsoil	< 5°	potential access	17	LOW	- bad res (Attachie) - left bank P.River
'HaRl-21'	1.5	468	248	Loose Sands, Silts, Topsoil	< 5°	low access	16	LOW	- right bank P.R adjacent outlet of small stream that flows into the P.R. - lower terrace
'HbRi-42'	8.2	460	230	Loose Sands, Silts, Topsoil	< 5°	potential access	37	MODERATE	- bad resolution GE image (Attachie) - left bench P.R. lower terrace
'HaRk-43'	0.7	466	220	Loose Sands, Silts, Topsoil	< 5°	low access	8	LOW	- lower terrace btw elongate relict fluvial deposits
'HbRg-49'	8.6	455	305	Loose Sands, Silts, Topsoil	> 25°	low access	36	MODERATE	- slope break btw mid & lower slope
'HbRg-52'	6.3	463	305	Loose Sands, Silts, Topsoil	> 25°	low access	48	HIGH	- narrow shelf on mid terrace at rise to upper terrace
'HbRh-136'	5.9	468	70	Loose Sands, Silts, Topsoil	5° to 25°	low access	12	LOW	-mid terrace in just upslope from depressional area on Bear Flat adjacent limestone quarry
'HbRh-140'	1.9	460	230	Loose Sands, Silts, Topsoil	< 5°	low access	16	LOW	- mid terrace near limestone outcrops?
'HbRh-141'	7.4	464	231	Loose Sands, Silts, Topsoil	> 25°	low access	64	HIGH	- just back from slope break on mid terrace - potential flow-slide colluvium
'HaRk-16'	2.6	448	250	Loose Sands, Silts, Topsoil	< 5°	low access	16	LOW	- on relict fluvial landform (lower terrace) left side P.River
'HbRi-61'	18	456	232	Loose Sands, Silts, Topsoil	5° to 25°	potential access	53	HIGH	- lower terrace, right side Halfway Ck 2.7km upstream from outlet
'HbRi-59'	13.2	451	235	Loose Sands, Silts, Topsoil	< 5°	known or apparent access	34	MODERATE	-Attachie, lower terrace, outlet of Halfway Ck
'HbRg-27'	1.8	467	235	Loose Sands, Silts, Topsoil	< 5°	known or apparent access	26	MODERATE	-mid terrace, adjacent resource road, ~100 m from slope break

Site Specific E-PAST Results
Archaeology

Site	Fetch Length (km)	Elevation of Site (m.amsl)	Exposure	Terrain Composition	Slope	Access	Score	Rating	Comments
'HbRg-16'	11.1	475	306	Loose Sands, Silts, Topsoil	5° to 25°	low access	36	MODERATE	-right bank Peace River plateau near slope break
'HaRk-13'	1.25	454	177	Loose Sands, Silts, Topsoil	< 5°	low access	6	LOW	-immediately downstream on the Peace River from outlet of the Moberly River
'HbRf-29'	5	415	105	Loose Sands, Silts, Topsoil	5° to 25°	low access	0	LOW	- right bank of P.River at outlet of Moberly Rv - 20m from present water level
'HaRj-7'	5	415	105	Loose Sands, Silts, Topsoil	5° to 25°	low access	0	LOW	
'HaRk-18'	4.7	467	233	Loose Sands, Silts, Topsoil	< 5°	potential access	37	MODERATE	-lower terrace, near residence (out-building)
'HaRk-26'	4.5	467	45	Loose Sands, Silts, Topsoil	< 5°	known or apparent access	18	LOW	-mid terrace, adjacent hwy 29
'HaRk-36'	4.4	465	45	Loose Sands, Silts, Topsoil	< 5°	low access	8	LOW	-mid terrace, adjacent hwy 29
'HbRg-46'	4.1	464	276	Loose Sands, Silts, Topsoil	> 25°	low access	48	HIGH	-on slope break between uppper and mid terrace
'HbRh-116'	8	460	254	Loose Sands, Silts, Topsoil	< 5°	known or apparent access	42	HIGH	-at slope break between lower and mid terrace -at disturbed area within agricultural setting
'HbRh-122'	3.3	454	209	Loose Sands, Silts, Topsoil	5° to 25°	low access	24	LOW	-mid terrace
'HbRh-130'	1.5	458	155	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	28	MODERATE	-adjacent hwy 29 on mid-terrace - adjacent limestone quarry on Bear Flat
'HbRh-129'	2.54	443	220	Loose Sands, Silts, Topsoil	5° to 25°	low access	12	LOW	-adjacent hwy 29 on mid-terrace - adjacent limestone quarry on Bear Flat -near slope break to modern floodplain of the P. River
'HaRk-2'	4.3	458	20.4	Loose Sands, Silts, Topsoil	< 5°	low access	8	LOW	-active floodplain of P. River vegetated point bar deposit
'HaRk-1'	5	461	248	Loose Sands, Silts, Topsoil	> 25°	known or apparent access	74	HIGH	-large polygon just downstream on the P. River from outlet of Farrell Ck. -adjacent hwy 29 with residence at east end - at slope break to active floodplain of P. River on mid-terrace
'HbRg-15'	7.3	470	306	Loose Sands, Silts, Topsoil	5° to 25°	low access	36	MODERATE	large polygon 1.7 km x 0.6 km on uppper terrace extends to active P. River bank
'HbRh-2'	4.7	458	214	Loose Sands, Silts, Topsoil	> 25°	potential access	69	HIGH	adjacent hwy 29 on banks of Cache Ck, upper terrace
'HbRf-59'	7.8	433	86	Loose Sands, Silts, Topsoil	5° to 25°	low access	0	LOW	on modern P. River floodplain just downstream from Moberly outlet
'HbRi-25'	13	455	236	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	46	HIGH	near Attachie, Bad res GE image, known or apparent access assumed given proximity to Attachie
'HaRl-20'	3.2	467	238	Loose Sands, Silts, Topsoil	5° to 25°	low access	36	MODERATE	active floodplain P. River adjacent Hudson Hope
'HaRk-37'	6.3	466	260	Loose Sands, Silts, Topsoil	> 25°	low access	64	HIGH	At top of modern P.River bank
'HbRg-47'	6	460	305	Loose Sands, Silts, Topsoil	> 25°	potential access	53	HIGH	At top of modern P.River bank

Site Specific E-PAST Results
Archaeology

Site	Fetch Length (km)	Elevation of Site (m.amsl)	Exposure	Terrain Composition	Slope	Access	Score	Rating	Comments
'HbRg-51'	8.7	463	305	Loose Sands, Silts, Topsoil	5° to 25°	potential access	41	HIGH	Upper terrace at head of gully feature, surrounding agricultural land.
'HbRg-54'	7.2	456	307	Loose Sands, Silts, Topsoil	5° to 25°	low access	27	MODERATE	on narrow bench of mid terrace between upper terrace and active bank of P. River
'HbRh-128'	1.6	458	180	Loose Sands, Silts, Topsoil	< 5°	low access	12	LOW	on Bear Flat near limestone quarry
'HbRh-127'	1.1	457	181	Loose Sands, Silts, Topsoil	< 5°	potential access	21	LOW	on Bear Flat near limestone quarry
'HbRh-138'	2.4	450	213	Loose Sands, Silts, Topsoil	5° to 25°	low access	24	LOW	on Bear Flat near limestone quarry, mid terrace at top of slope break to active floodplain of P. River
'HbRi-24'	12.1	450	237	Loose Sands, Silts, Topsoil	5° to 25°	potential access	41	HIGH	At Attachie bad resolution GE image
'HaRl-22'	3.7	464	236	Loose Sands, Silts, Topsoil	< 5°	low access	24	LOW	active floodplain P. River adjacent Hudson Hope
'HaRl-24'	3.8	462	236	Loose Sands, Silts, Topsoil	< 5°	low access	24	LOW	active floodplain P. River adjacent Hudson Hope
'HbRh-30'	1.4	453	205	Loose Sands, Silts, Topsoil	5° to 25°	low access	12	LOW	in gully feature on mid terrace
'HbRh-52'	2.2	447	209	Loose Sands, Silts, Topsoil	< 5°	low access	16	LOW	lower terrace near Bear Flat
'HaRl-4'	0.6	464	250	Loose Sands, Silts, Topsoil	> 25°	low access	16	LOW	active floodplain P. River adjacent Hudson Hope
'HbRh-112'	8.5	464	256	Loose Sands, Silts, Topsoil	< 5°	low access	32	MODERATE	On Bear Flat mid terrace
'HbRf-100'	8.5	461	90	Loose Sands, Silts, Topsoil	5° to 25°	low access	12	LOW	at slope break from terace to modern P. River floodplain
'HbRi-60'	12.5	456	236	Loose Sands, Silts, Topsoil	5° to 25°	potential access	41	HIGH	At Attachie bad resolution GE image
'HbRh-117'	7	464	257	Loose Sands, Silts, Topsoil	< 5°	potential access	37	MODERATE	mid terrace adjacent agricultural settlement
'HbRh-132'	1.7	457	141	Loose Sands, Silts, Topsoil	< 5°	low access	12	LOW	On Bear Flat mid terrace
'HbRh-135'	4.4	450	197	Organics	< 5°	low access	36	MODERATE	On Bear Flat mid terrace
'HaRk-48'	1.8	466	183	Loose Sands, Silts, Topsoil	< 5°	potential access	21	LOW	Upper terrace adjacent hwy 29
'HaRk-50'	2.5	464	178	Loose Sands, Silts, Topsoil	< 5°	low access	18	LOW	mid terrace adjacent agricultural settlement
'HaRk-51'	14	445	52	Loose Sands, Silts, Topsoil	5° to 25°	low access	6	LOW	at banks of modern day P. River, will be inundated
'HaRl-19'	2.2	458	195	Loose Sands, Silts, Topsoil	> 25°	known or apparent access	58	HIGH	On P. River access road modern floodplain
'HbRg-61'	4.5	466	296	Loose Sands, Silts, Topsoil	< 5°	potential access	29	MODERATE	mid terrace
'HbRh-114'	8.3	460	254	Loose Sands, Silts, Topsoil	> 25°	low access	64	HIGH	At slope break of mid terrace

Site	HaRf-61	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7.8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 466 m

Depth (m): 0.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

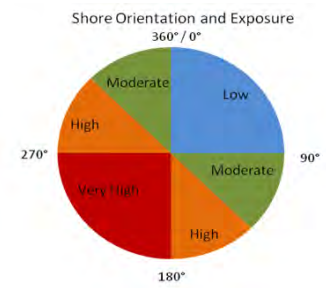
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	TRUE	FALSE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 1

Exposure to waves and currents: 86 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	1	*"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 16

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 26

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRg-53	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6.1 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 461 m

Depth (m): 5.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

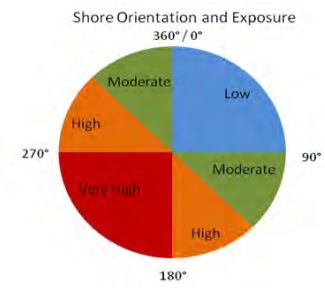
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 305 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 58

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRg-6	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 462 m

Depth (m): 4.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

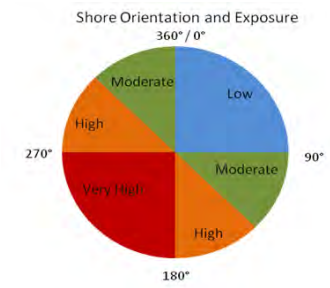
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 287 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 46

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRg-5	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 462 m

Depth (m): 4.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

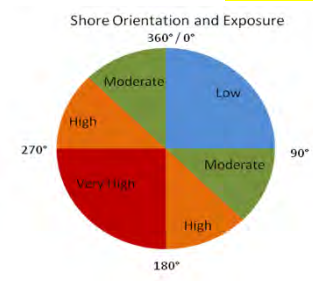
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 287 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 46

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-18	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 463 m

Depth (m): 3.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

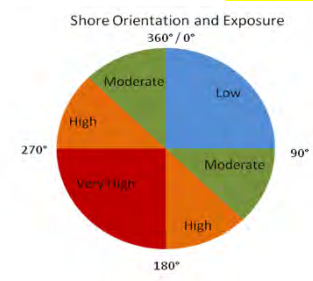
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 287 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 41

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-11	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 470 m

Depth (m): -3.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

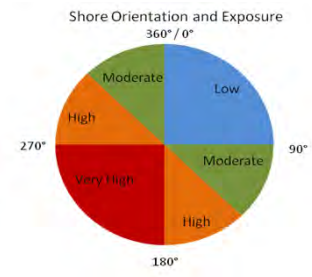
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	TRUE	FALSE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 1

Exposure to waves and currents: 90 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 1 *"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 16

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 26

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRh-37	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.1 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

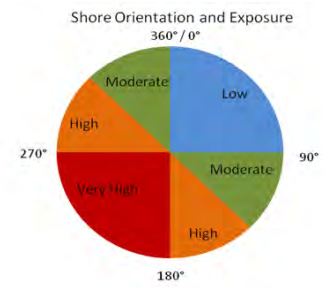
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 204 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 46

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-34	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 10.2 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 453 m

Depth (m): 13.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

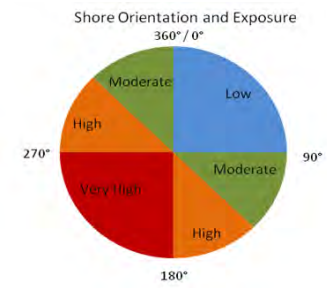
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 253 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 41

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRk-23	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7.75 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 448 m

Depth (m): 18.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

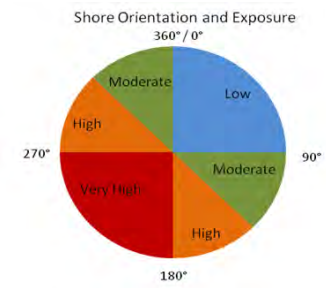
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 260 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 24

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 29

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRh-6	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 462 m

Depth (m): 4.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

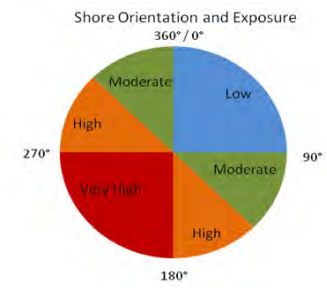
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 257 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 58

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-36	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

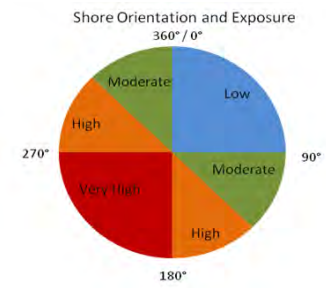
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 240 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 4

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient	Qualitative	Shallow	Moderate	Steep
	Measured Slope	< 5°	5° to 25°	> 25°
	Bedrock or Armoured	0	0	0
	Hard Till; Cobbles	-1	0	0
	Loose Till	-1	0	+1
	Loose Sands, Silts, Topsoil	-1	0	+1
	Organics	0	+1	+1
	Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 46

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRi-43	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 9.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 457 m

Depth (m): 9.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

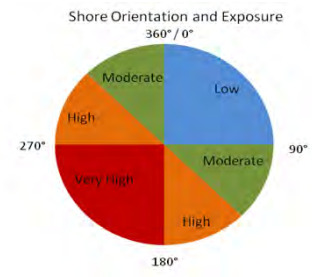
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 231 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 42

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRj-28	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 449 m

Depth (m): 17.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

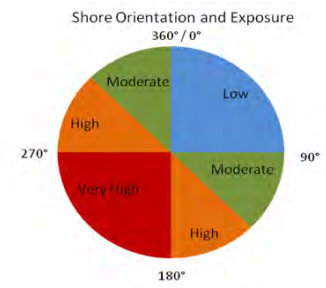
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 245 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **5° to 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 36

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRj-14	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5.9 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

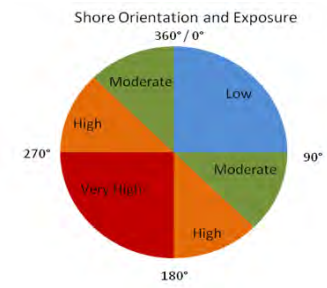
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 238 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 64

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 64

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRj-19	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5.4 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 456 m

Depth (m): 10.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

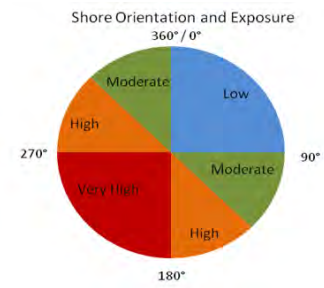
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 238 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 48

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRk-35	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 462 m

Depth (m): 4.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

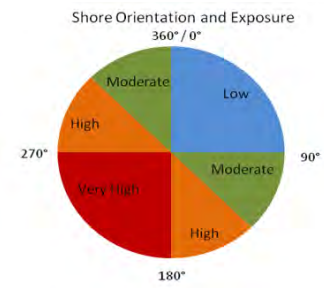
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 260 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **5° to 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRk-38	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6.35 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 462 m

Depth (m): 4.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

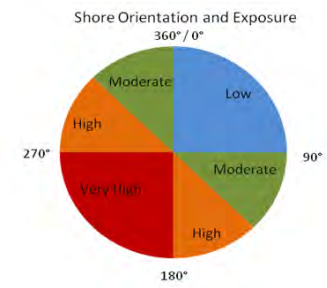
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 260 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*
Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **> 25°**

Slope Gradient	Qualitative	Shallow	Moderate	Steep
	Measured Slope	< 5°	5° to 25°	> 25°
	Bedrock or Armoured	0	0	0
	Hard Till; Cobbles	-1	0	0
	Loose Till	-1	0	+1
	Loose Sands, Silts, Topsoil	-1	0	+1
	Organics	0	+1	+1
	Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 64

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 69

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRg-17	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **6.5** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **459** m

Depth (m): 7.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **4**

I-2 Terrain Exposure

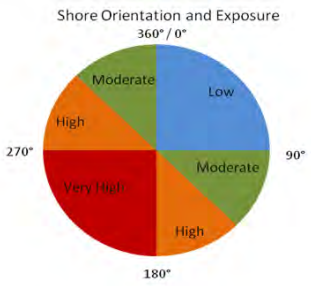
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **225** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **16**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **32**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **32**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **MODERATE**

Site	HbRh-113	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 462 m

Depth (m): 4.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

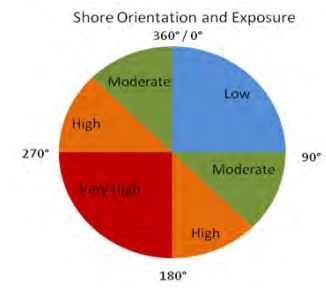
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 257 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **5° to 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-65	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 10 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro
Probable maximum flood elevation: 466.3 m
Elevation of site (e.g., based on LiDAR): 463 m
Depth (m): 3.3 m
Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

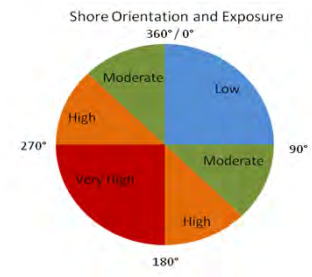
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 252 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 37

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRh-120	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: **3**

Fetch length (e.g., from Google Earth): **2.7** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: **-2**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **445** m

Depth (m): 21.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **1**

I-2 Terrain Exposure

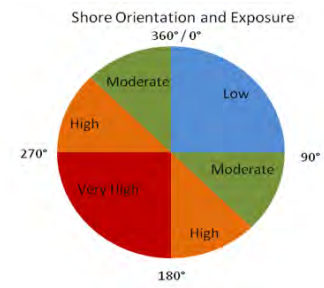
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **215** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **1** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **4**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **+1**

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **4**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **16**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **16**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRh-121	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **0**

Fetch length (e.g., from Google Earth): **4** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **448** m

Depth (m): 18.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **0**

I-2 Terrain Exposure

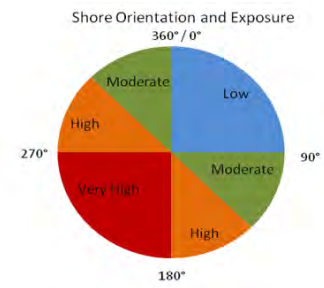
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **213** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **0**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **0**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **0**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRh-124	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: **3**

Fetch length (e.g., from Google Earth): **3.5** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **456** m

Depth (m): 10.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

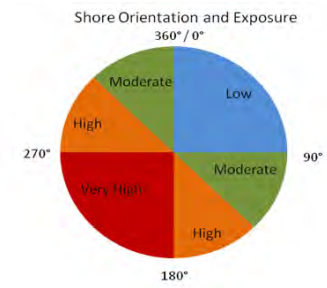
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **211** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **2** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **24**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **24**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRh-16	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 470 m

Depth (m): -3.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

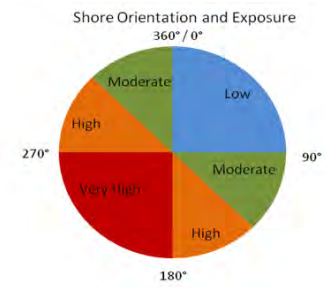
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 217 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRi-41	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 0

Fetch length (e.g., from Google Earth): 1 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 465 m

Depth (m): 1.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 0

I-2 Terrain Exposure

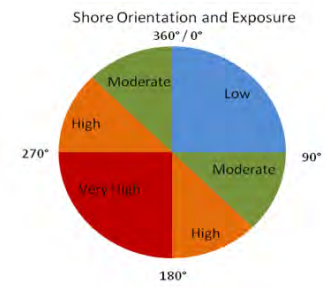
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	TRUE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 2

Exposure to waves and currents: 350 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	2	*"Exposure Score" from Step 4*

DRIVING FORCES: 0

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 0

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 5

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRj-22	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 459 m

Depth (m): 7.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

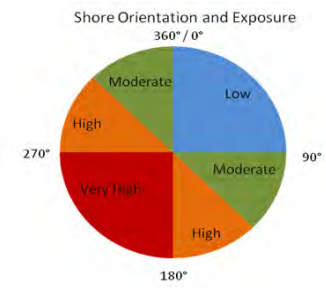
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 248 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 32

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRI-10	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 13.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 462 m

Depth (m): 4.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

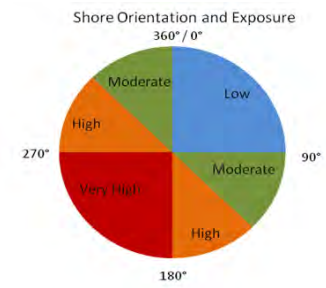
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 225 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-29	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 9.8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: -4

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 436 m

Depth (m): 30.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 0

I-2 Terrain Exposure

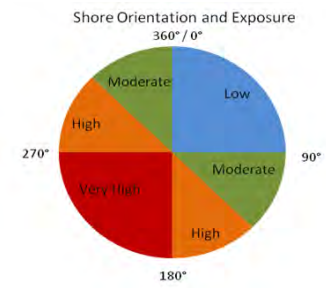
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 265 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 0

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 0

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 0

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-20	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **10.5** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **466** m

Depth (m): 0.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **4**

I-2 Terrain Exposure

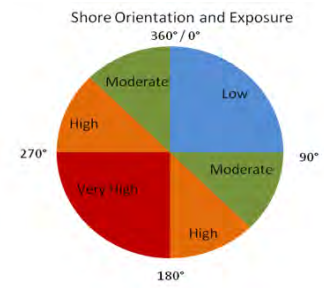
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	TRUE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **2**

Exposure to waves and currents: **110** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **4** *"Modified Fetch" from Step 3*

Exposure Score: **2** *"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **16**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **21**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRh-61	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 9.8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 461 m

Depth (m): 5.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

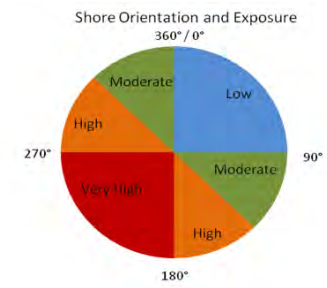
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 265 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 58

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRf-42	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: -4

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 416 m

Depth (m): 50.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 0

I-2 Terrain Exposure

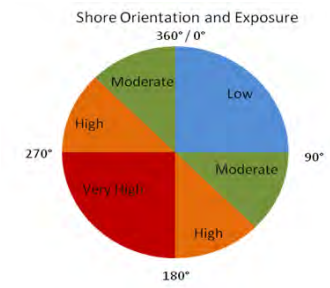
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 296 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 0

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient	Qualitative	Shallow	Moderate	Steep
	Measured Slope	< 5°	5° to 25°	> 25°
	Bedrock or Armoured	0	0	0
	Hard Till; Cobbles	-1	0	0
	Loose Till	-1	0	+1
	Loose Sands, Silts, Topsoil	-1	0	+1
	Organics	0	+1	+1
	Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 0

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 0

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRj-24	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 459 m

Depth (m): 7.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

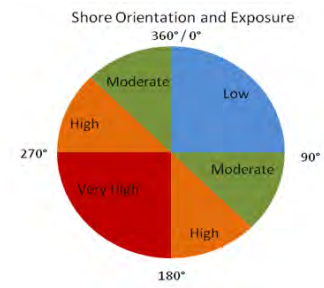
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 248 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 32

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRI-23	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.1 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 461 m

Depth (m): 5.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

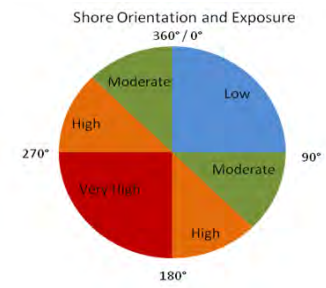
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 235 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 58

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-107	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

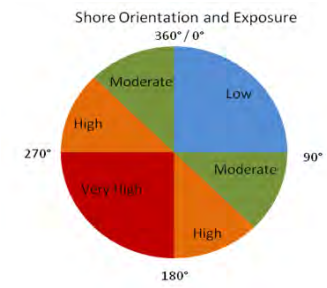
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 203 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 36

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRg-48	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 458 m

Depth (m): 8.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

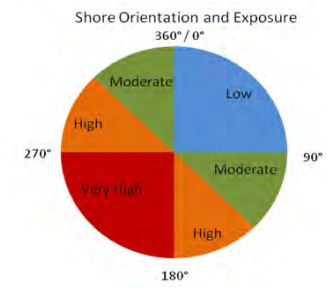
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 306 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 36

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRg-56	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **7** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: **-2**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **446** m

Depth (m): 20.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

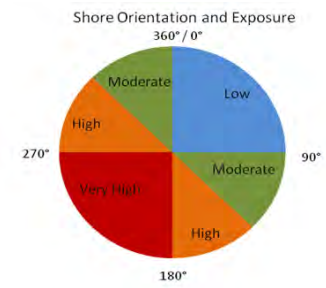
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **3**

Exposure to waves and currents: **306** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **2** *"Modified Fetch" from Step 3*

Exposure Score: **3** *"Exposure Score" from Step 4*

DRIVING FORCES: **6**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **18**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **18**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRg-57	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **6.3** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **457** m

Depth (m): 9.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **4**

I-2 Terrain Exposure

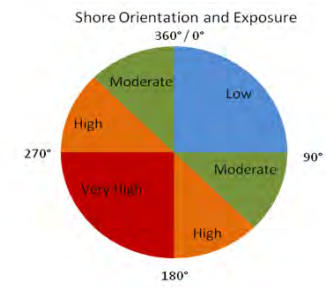
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **3**

Exposure to waves and currents: **305** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **+1**

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **4**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **48**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **48**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **HIGH**

Site	HbRi-56	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7.1 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 461 m

Depth (m): 5.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

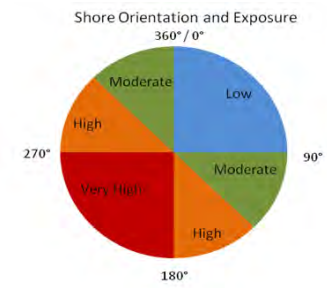
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 225 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRi-58	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 11.6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 457 m

Depth (m): 9.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

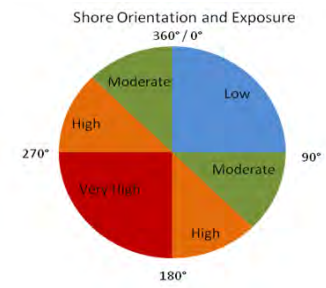
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 236 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRk-46	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **7.7** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **449** m

Depth (m): 17.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **3**

I-2 Terrain Exposure

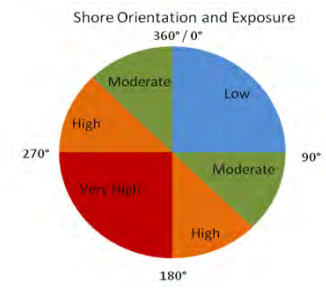
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **260** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **3** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **24**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **24**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HaRj-27	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5.7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 458 m

Depth (m): 8.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

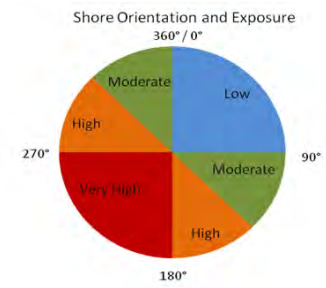
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 236 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 48

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-133	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): **4.4** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **462** m

Depth (m): 4.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

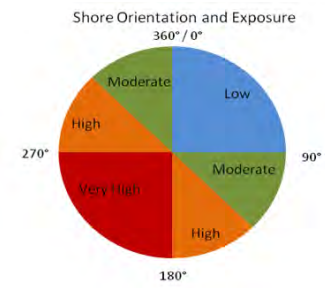
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: **225** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **5° to 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-126	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 452 m

Depth (m): 14.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

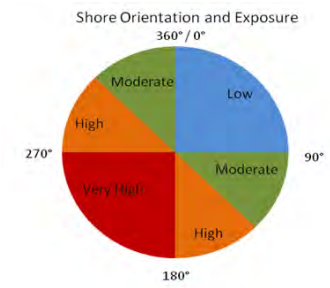
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 203 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 2 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 8

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Organics**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 24

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 24

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-134	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.2 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 457 m

Depth (m): 9.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

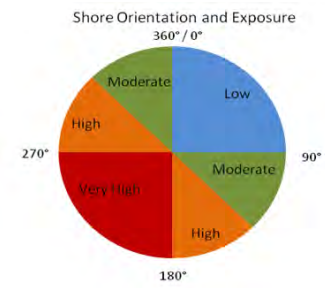
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 203 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Organics**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient	Qualitative	Shallow	Moderate	Steep
	Measured Slope	< 5°	5° to 25°	> 25°
	Bedrock or Armoured	0	0	0
	Hard Till; Cobbles	-1	0	0
	Loose Till	-1	0	+1
	Loose Sands, Silts, Topsoil	-1	0	+1
	Organics	0	+1	+1
	Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 36

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRh-139	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **4.4** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: **-2**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **438** m

Depth (m): 28.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

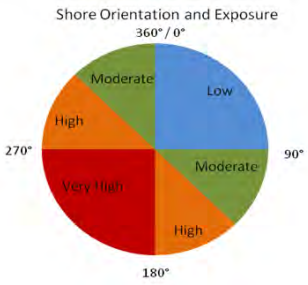
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **235** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **+1**

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **4**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **32**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **32**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **MODERATE**

Site	HbRh-139	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 470 m

Depth (m): -3.7 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

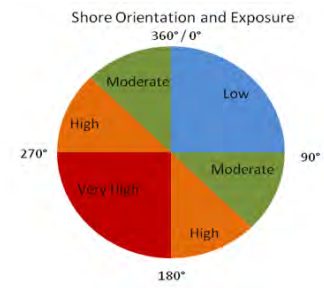
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 237 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 32

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRk-10	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 470 m

Depth (m): -3.7 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

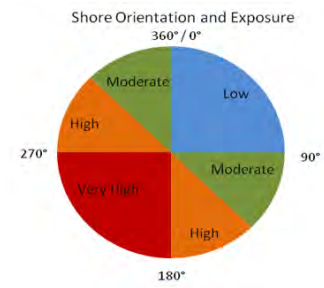
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 237 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 32

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRh-53	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 450 m

Depth (m): 16.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

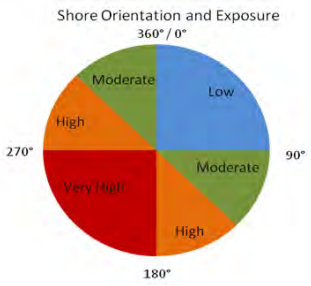
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 206 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 2 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 8

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Organics**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 24

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 24

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRk-5	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 464 m

Depth (m): 2.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

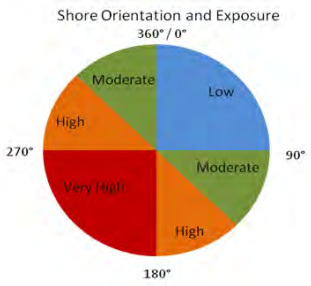
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 197 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 48

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-45	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3.7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: -4

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 424 m

Depth (m): 42.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 0

I-2 Terrain Exposure

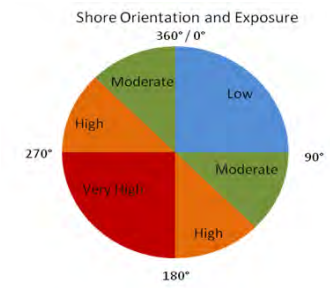
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 315 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 0

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 0

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 0

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-35	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **7.4** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: **-4**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **434** m

Depth (m): 32.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **0**

I-2 Terrain Exposure

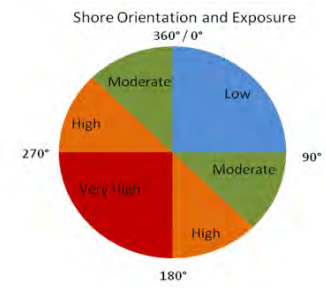
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **262** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **0**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **0**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **5**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRi-10	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 11.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: -2

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 442 m

Depth (m): 24.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

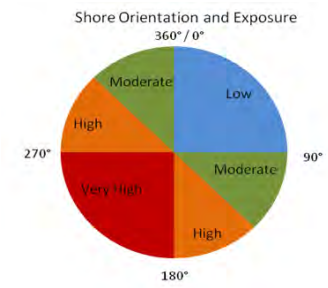
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 237 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 8

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient	Qualitative	Shallow	Moderate	Steep
	Measured Slope	< 5°	5° to 25°	> 25°
	Bedrock or Armoured	0	0	0
	Hard Till; Cobbles	-1	0	0
	Loose Till	-1	0	+1
	Loose Sands, Silts, Topsoil	-1	0	+1
	Organics	0	+1	+1
	Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 16

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 21

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-66	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.8** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **453** m

Depth (m): 13.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **1**

I-2 Terrain Exposure

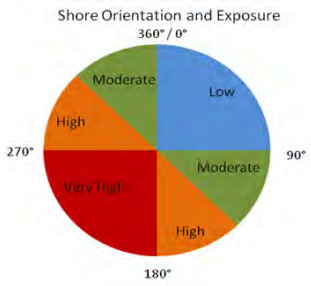
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **3**

Exposure to waves and currents: **180** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **1** *"Modified Fetch" from Step 3*

Exposure Score: **3** *"Exposure Score" from Step 4*

DRIVING FORCES: **3**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Organics**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **9**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **9**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRh-46	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.8** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: **-2**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **445** m

Depth (m): 21.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **0**

I-2 Terrain Exposure

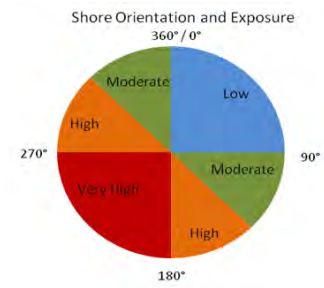
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **185** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **0**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **0**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **0**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HaRk-44	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6.9 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 463 m

Depth (m): 3.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

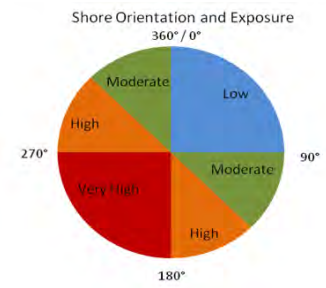
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 258 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 64

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 64

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-67	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 457 m

Depth (m): 9.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

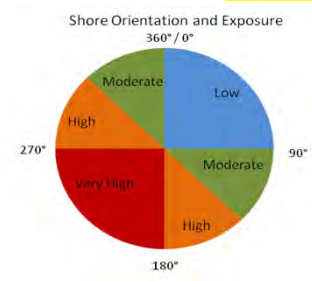
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 252 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 37

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRh-32	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **10.3** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: **-4**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **432** m

Depth (m): 34.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **0**

I-2 Terrain Exposure

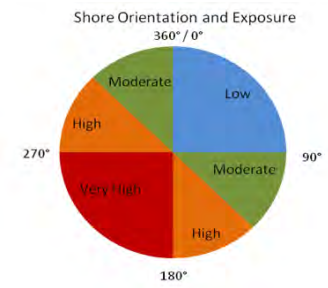
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **265** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **0**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **0**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **0**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRj-6	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 12 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

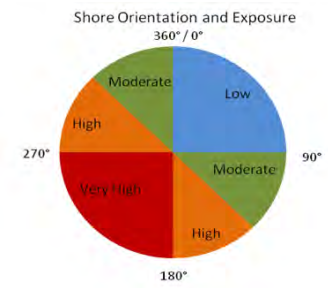
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 230 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **> 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 64

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 64

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRk-38	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **11** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **450** m

Depth (m): 16.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **3**

I-2 Terrain Exposure

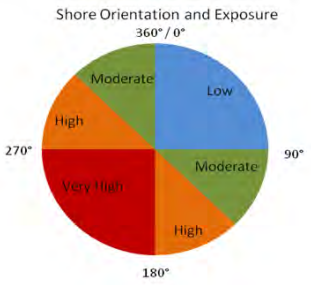
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **250** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **3** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **4**

Terrain Composition *(select from drop-down)*: **Organics**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **4**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **48**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **53**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **HIGH**

Site	HbRf-62	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: -4

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 436 m

Depth (m): 30.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 0

I-2 Terrain Exposure

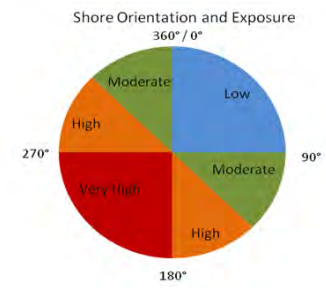
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	TRUE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 2

Exposure to waves and currents: 105 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	2	*"Exposure Score" from Step 4*

DRIVING FORCES: 0

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 0

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 0

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

APPENDIX M-1
Site Specific E-PAST Results
Archaeology

Site	HbRh-7	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **12.1** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **467** m

Depth (m): -0.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **4**

I-2 Terrain Exposure

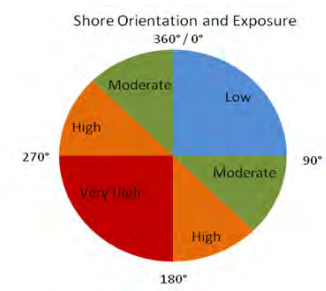
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **250** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **4** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **16**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **32**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **37**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **MODERATE**

Site	HbRh-19	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

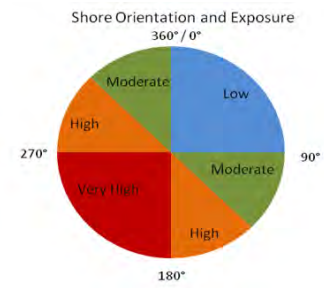
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 225 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRj-10	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE

FETCH SCORE: **5**

Fetch length (e.g., from Google Earth): **20.2** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: **-2**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **440** m

Depth (m): 26.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **3**

I-2 Terrain Exposure

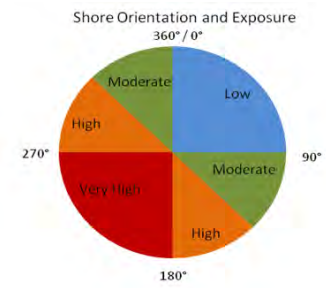
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **250** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **24**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **24**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRh-8	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8.9 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 466 m

Depth (m): 0.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

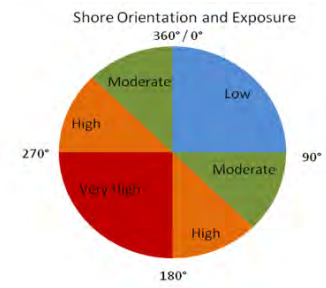
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 258 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 64

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 69

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRk-45	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.4** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **467** m

Depth (m): -0.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

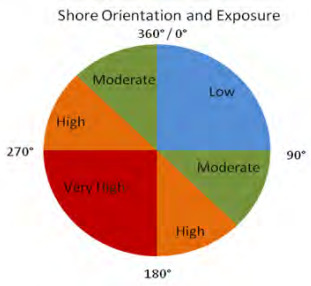
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **185** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **2** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **16**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **21**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRg-50	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.35** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **465** m

Depth (m): 1.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

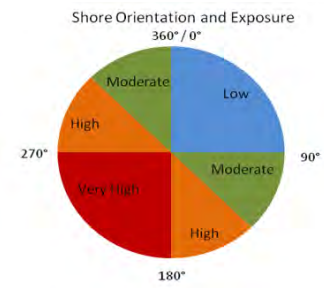
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **3**

Exposure to waves and currents: **179** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: **6**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **12**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **12**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRh-115	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 458 m

Depth (m): 8.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

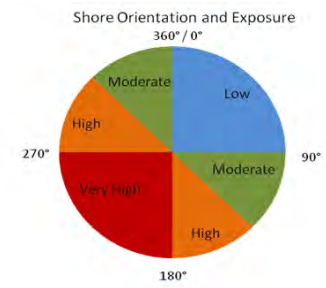
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 256 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 58

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-137	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 468 m

Depth (m): -1.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

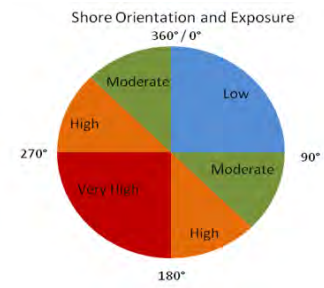
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 217 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 41

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-142	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.9** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: **-4**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **432** m

Depth (m): 34.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **0**

I-2 Terrain Exposure

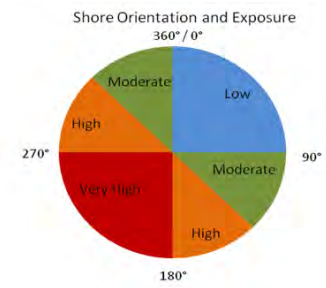
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **3**

Exposure to waves and currents: **311** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: **0**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **+1**

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **4**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **0**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **0**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HaRk-49	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.4 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro
Probable maximum flood elevation: 466.3 m
Elevation of site (e.g., based on LiDAR): 462 m
Depth (m): 4.3 m
Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

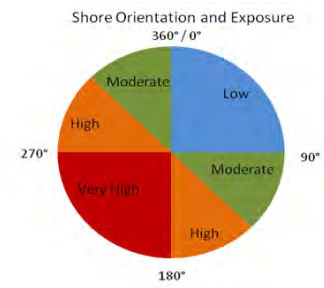
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 180 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 9

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 27

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 37

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRg-28	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): **6.3** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **473** m

Depth (m): -6.7 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

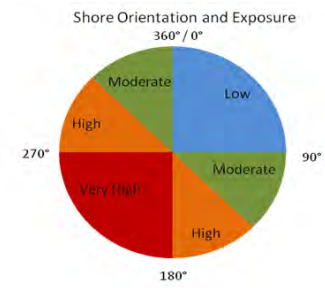
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: **305** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 41

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-56	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 459 m

Depth (m): 7.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

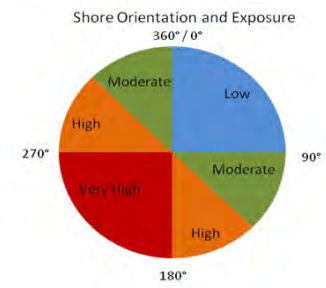
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 252 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 37

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRk-12	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 470 m

Depth (m): -3.7 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

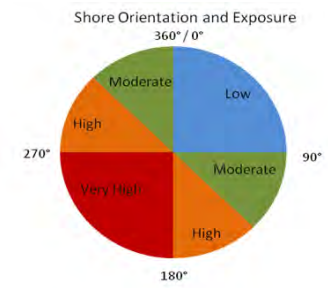
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 250 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **5° to 25°**

Slope Gradient	Qualitative	Shallow	Moderate	Steep
	Measured Slope	< 5°	5° to 25°	> 25°
	Bedrock or Armoured	0	0	0
	Hard Till; Cobbles	-1	0	0
	Loose Till	-1	0	+1
	Loose Sands, Silts, Topsoil	-1	0	+1
	Organics	0	+1	+1
	Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRi-11	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **14.3** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: **-2**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **440** m

Depth (m): 26.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

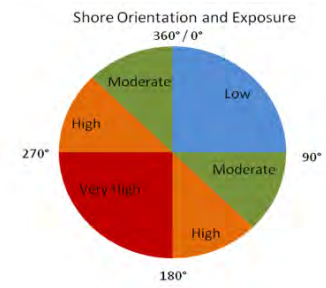
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **236** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **16**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **16**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HaRi-12	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 14.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: -2

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 442 m

Depth (m): 24.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

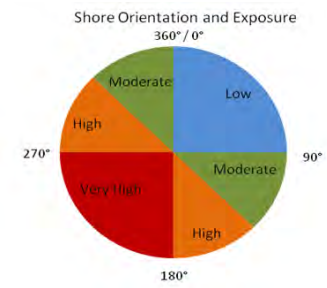
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 236 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 2 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 8

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 16

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 16

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRI-3	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 2

Fetch length (e.g., from Google Earth): 1.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 470 m

Depth (m): -3.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

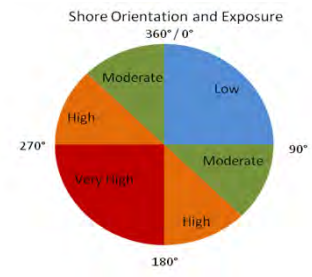
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 245 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 2 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 8

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 37

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRl-7	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 11.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro
Probable maximum flood elevation: 466.3 m
Elevation of site (e.g., based on LiDAR): 465 m
Depth (m): 1.3 m
Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

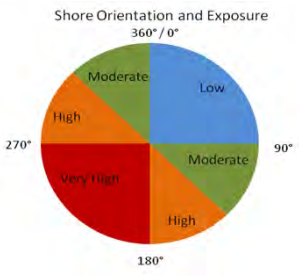
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	TRUE	FALSE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 1

Exposure to waves and currents: 46 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 1 *"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 12

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 12

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-18	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 470 m

Depth (m): -3.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

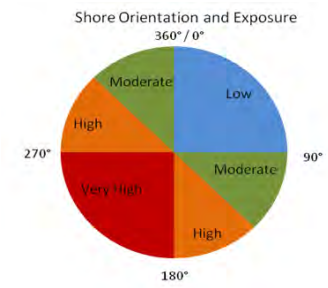
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 225 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRk-25	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.1 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 466 m

Depth (m): 0.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

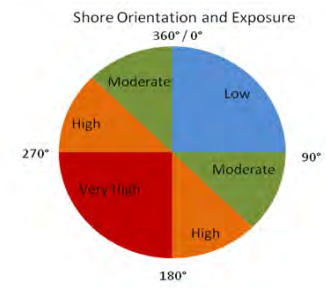
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 180 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 9

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 27

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 32

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRg-55	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 454 m

Depth (m): 12.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

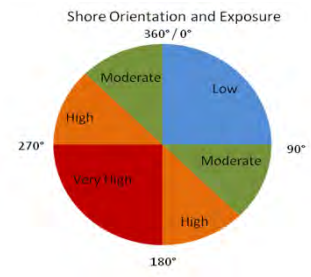
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 305 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 9

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **> 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 41

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRi-57	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **13** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **454** m

Depth (m): 12.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **3**

I-2 Terrain Exposure

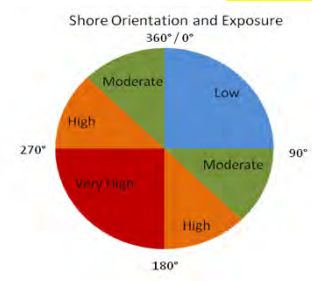
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **235** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **3** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **24**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **10**

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **34**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **MODERATE**

Site	HbHr-123	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: **3**

Fetch length (e.g., from Google Earth): **2.8** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **454** m

Depth (m): 12.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

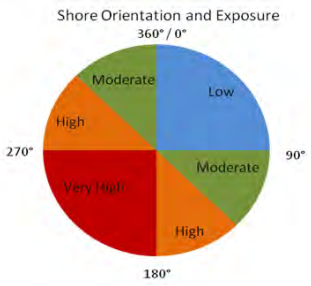
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **185** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **2** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **24**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **24**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRh-125	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 456 m

Depth (m): 10.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

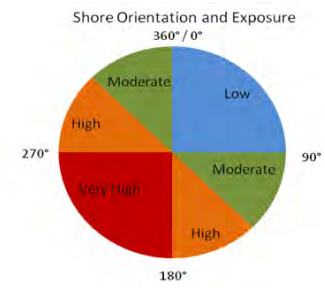
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 177 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 6

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 12

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 17

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-131	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **7.5** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **448** m

Depth (m): 18.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **3**

I-2 Terrain Exposure

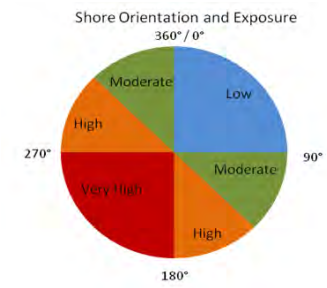
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **253** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **+1**

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **4**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **48**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **48**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **HIGH**

Site	HbRh-58	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7.8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 464 m

Depth (m): 2.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

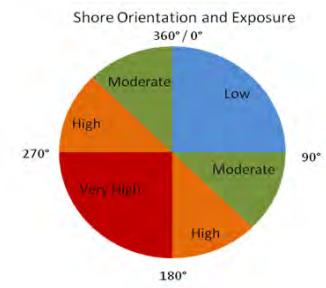
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 245 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 37

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRh-104	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 454 m

Depth (m): 12.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

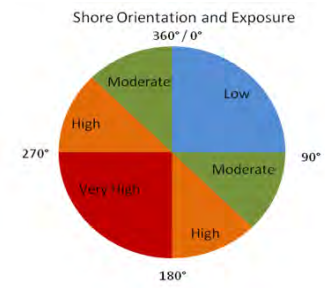
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 217 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **> 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRI-18	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 2

Fetch length (e.g., from Google Earth): 1.9 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 456 m

Depth (m): 10.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 1

I-2 Terrain Exposure

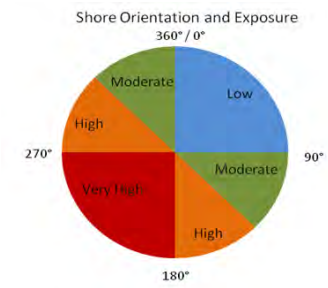
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 193 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	1	*"Modified Fetch" from Step 3*
Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 16

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 16

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRl-29	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **10.4** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **455** m

Depth (m): 11.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **3**

I-2 Terrain Exposure

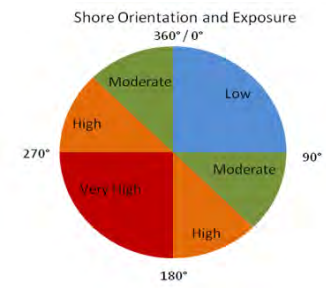
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **225** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **3** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **36**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **41**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **HIGH**

Site	HbRi-50	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 2

Fetch length (e.g., from Google Earth): 1.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 459 m

Depth (m): 7.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

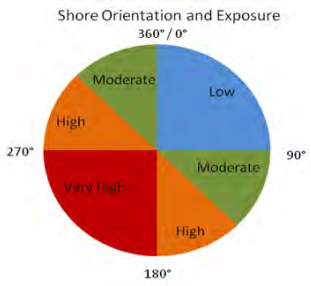
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 180 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 2 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 6

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 12

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 17

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRI-21	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 2

Fetch length (e.g., from Google Earth): 1.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 468 m

Depth (m): -1.7 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

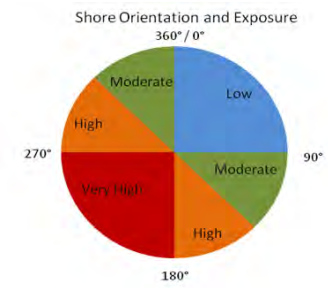
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 248 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 8

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 16

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 16

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRi-42	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8.2 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

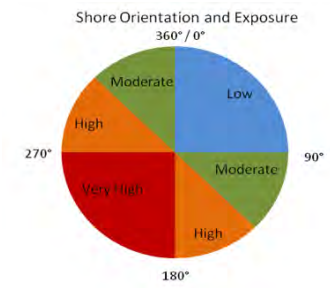
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 230 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 37

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRk-43	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 1

Fetch length (e.g., from Google Earth): 0.7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 466 m

Depth (m): 0.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 1

I-2 Terrain Exposure

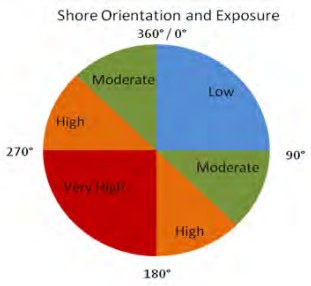
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 220 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 1 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 8

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 8

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRg-49	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8.6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 455 m

Depth (m): 11.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

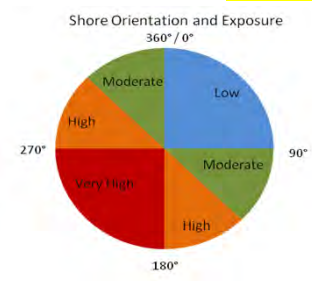
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 305 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 9

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 36

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRg-52	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 463 m

Depth (m): 3.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

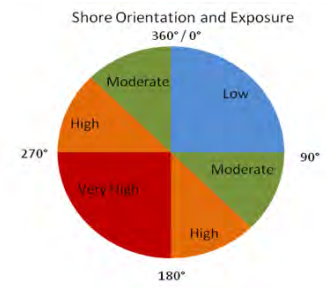
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 305 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **> 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 48

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-136	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5.9 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 468 m

Depth (m): -1.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

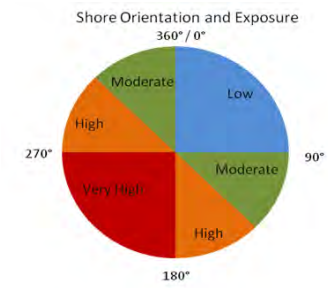
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	TRUE	FALSE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 1

Exposure to waves and currents: 70 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 1 *"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 12

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 12

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-140	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 2

Fetch length (e.g., from Google Earth): 1.9 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

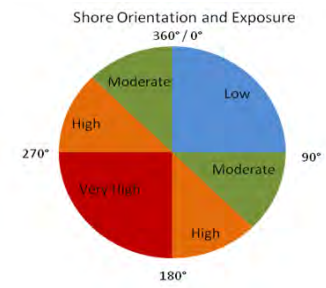
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 230 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 8

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient	Qualitative	Shallow	Moderate	Steep
	Measured Slope	< 5°	5° to 25°	> 25°
	Bedrock or Armoured	0	0	0
	Hard Till; Cobbles	-1	0	0
	Loose Till	-1	0	+1
	Loose Sands, Silts, Topsoil	-1	0	+1
	Organics	0	+1	+1
	Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 16

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 16

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-141	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7.4 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 464 m

Depth (m): 2.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

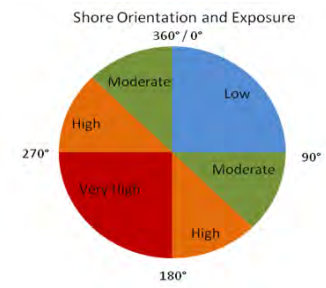
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 231 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 64

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 64

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRk-16	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 448 m

Depth (m): 18.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

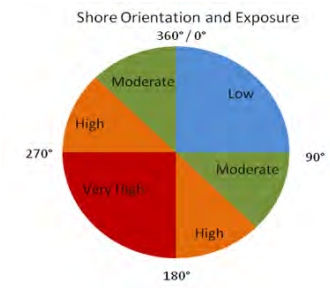
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 250 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 2 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 8

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 16

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 16

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRi-61	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE

FETCH SCORE: **5**

Fetch length (e.g., from Google Earth): **18** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **456** m

Depth (m): 10.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **4**

I-2 Terrain Exposure

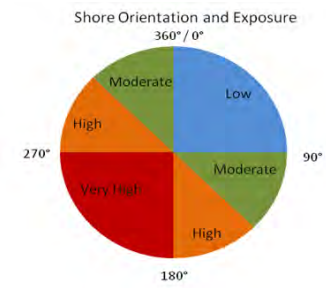
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **232** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **16**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **5° to 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **48**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **53**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **HIGH**

Site	HbRi-59	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **13.2** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **451** m

Depth (m): 15.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **3**

I-2 Terrain Exposure

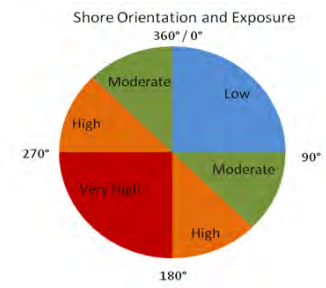
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **235** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **3** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **24**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **10**

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **34**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **MODERATE**

Site	HbRg-27	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.8** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **467** m

Depth (m): -0.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

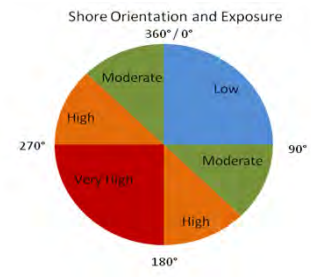
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **235** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **16**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **10**

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **26**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **MODERATE**

Site	HbRg-16	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **11.1** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **475** m

Depth (m): -8.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **4**

I-2 Terrain Exposure

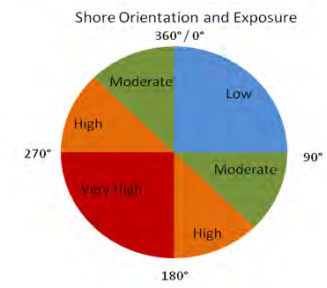
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **3**

Exposure to waves and currents: **306** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **36**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **36**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **MODERATE**

Site	HaRk-13	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.25** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **454** m

Depth (m): 12.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **1**

I-2 Terrain Exposure

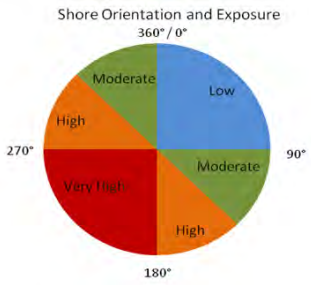
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **3**

Exposure to waves and currents: **177** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **1** *"Modified Fetch" from Step 3*

Exposure Score: **3** *"Exposure Score" from Step 4*

DRIVING FORCES: **3**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **6**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **6**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRf-29	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 415 m

Depth (m): 51.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: -4

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 0

I-2 Terrain Exposure

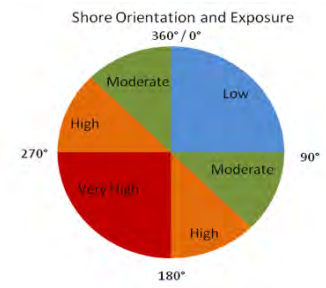
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	TRUE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 2

Exposure to waves and currents: 105 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	2	*"Exposure Score" from Step 4*

DRIVING FORCES: 0

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **5° to 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 0

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 0

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRf-29	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: -4

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 415 m

Depth (m): 51.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 0

I-2 Terrain Exposure

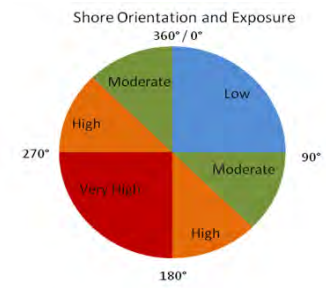
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	TRUE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 2

Exposure to waves and currents: 105 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	2	*"Exposure Score" from Step 4*

DRIVING FORCES: 0

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 0

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 0

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRk-18	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 467 m

Depth (m): -0.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

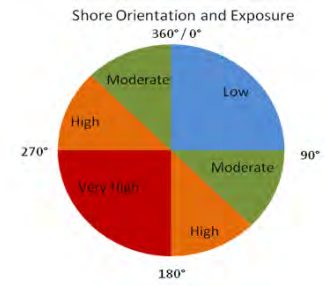
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 233 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 37

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRk-26	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 467 m

Depth (m): -0.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

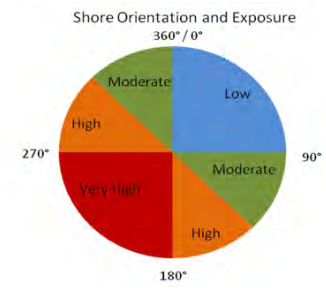
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	TRUE	FALSE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 1

Exposure to waves and currents: 45 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 1 *"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 8

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 18

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRk-36	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.4 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 465 m

Depth (m): 1.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

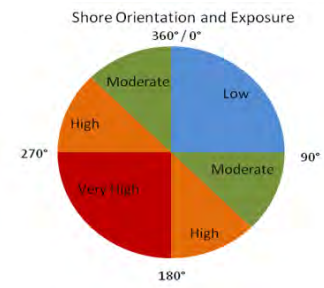
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	TRUE	FALSE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 1

Exposure to waves and currents: 45 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 1 *"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 8

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 8

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRg-46	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

I DRIVING FORCES

I-1 Fetch Length and Depth

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.1 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 464 m

Depth (m): 2.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

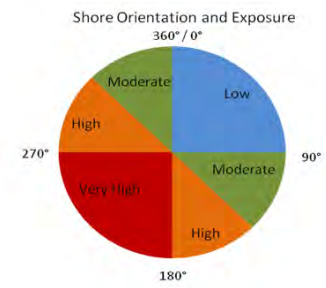
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 276 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient	Qualitative	Shallow	Moderate	Steep
	Measured Slope	< 5°	5° to 25°	> 25°
	Bedrock or Armoured	0	0	0
	Hard Till; Cobbles	-1	0	0
	Loose Till	-1	0	+1
	Loose Sands, Silts, Topsoil	-1	0	+1
	Organics	0	+1	+1
	Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 48

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-116	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

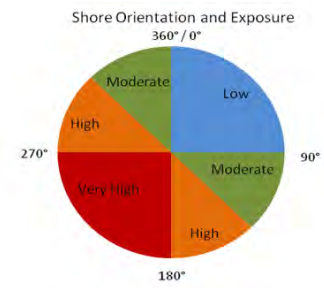
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 254 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 42

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRh-122	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro
Probable maximum flood elevation: 466.3 m
Elevation of site (e.g., based on LiDAR): 454 m
Depth (m): 12.3 m
Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

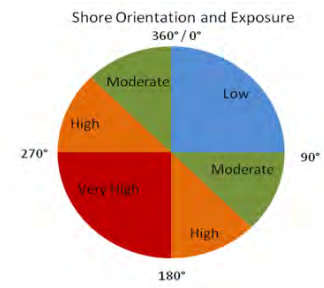
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 209 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 2 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 8

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **5° to 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 24

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 24

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-130	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.5** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **458** m

Depth (m): 8.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

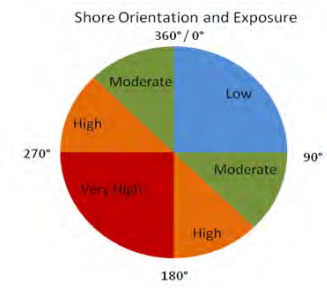
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **3**

Exposure to waves and currents: **155** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: **6**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **18**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **10**

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **28**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **MODERATE**

Site	HbRf-129	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.54 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: -2

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 443 m

Depth (m): 23.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 1

I-2 Terrain Exposure

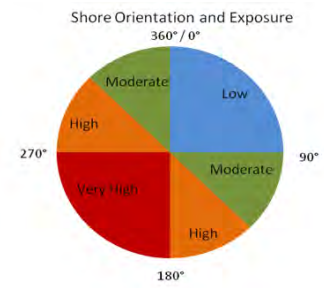
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 220 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 1 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 12

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 12

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRk-2	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 458 m

Depth (m): 8.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

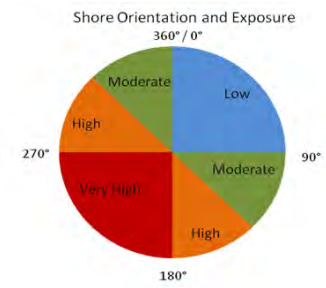
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	TRUE	FALSE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 1

Exposure to waves and currents: 20.4 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 1 *"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 8

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 8

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRk-1	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 461 m

Depth (m): 5.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

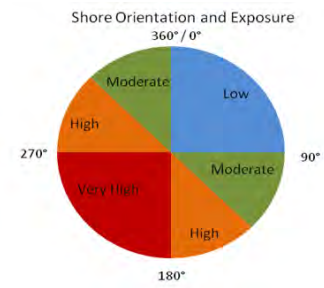
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 248 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

Slope Gradient *(select from drop-down)*: **> 25°**

TERRAIN MODIFIER: +1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 64

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 74

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRg-15	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 470 m

Depth (m): -3.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

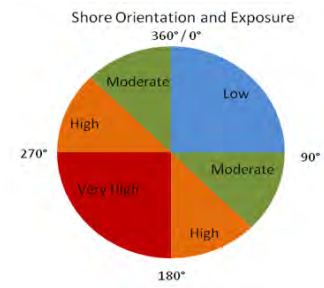
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 306 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 36

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRh-2	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 458 m

Depth (m): 8.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

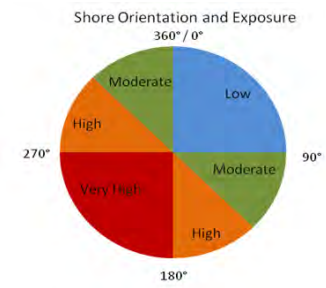
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 214 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 64

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 69

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRf-59	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **7.8** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: **-4**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **433** m

Depth (m): 33.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **0**

I-2 Terrain Exposure

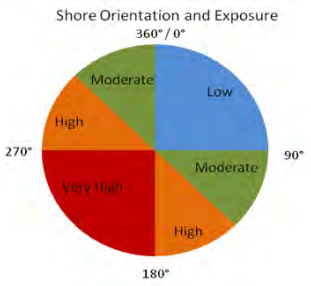
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	TRUE	FALSE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **1**

Exposure to waves and currents: **86** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	1	*"Exposure Score" from Step 4*

DRIVING FORCES: **0**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **0**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **0**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRi-25	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **13** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **455** m

Depth (m): 11.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **3**

I-2 Terrain Exposure

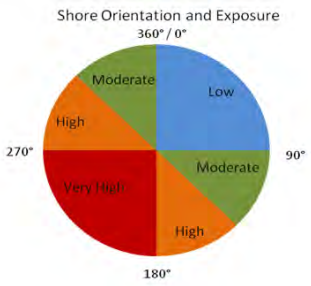
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **236** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **3** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **36**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **10**

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **46**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **HIGH**

Site	HaRI-20	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3.2 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 467 m

Depth (m): -0.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

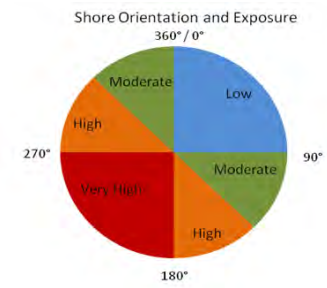
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 238 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 36

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRk-37	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 466 m

Depth (m): 0.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

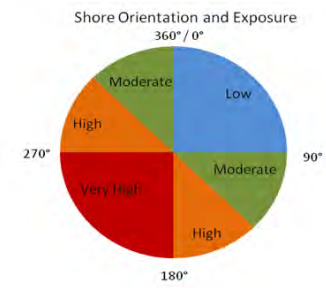
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 260 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 64

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 64

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRg-47	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

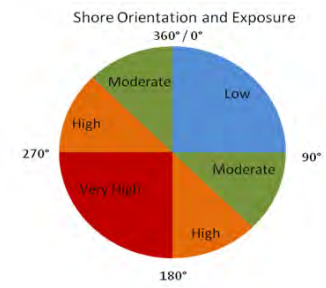
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 305 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **> 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 53

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRg-51	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8.7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 463 m

Depth (m): 3.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

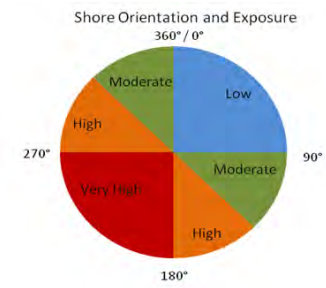
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 305 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 41

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRg-54	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7.2 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 456 m

Depth (m): 10.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

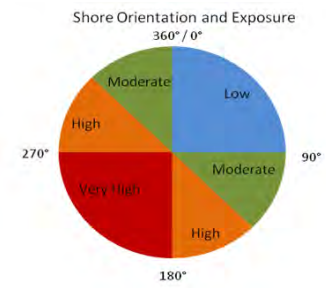
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 307 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*
Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 9

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 27

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 27

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRh-128	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 2

Fetch length (e.g., from Google Earth): 1.6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 458 m

Depth (m): 8.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

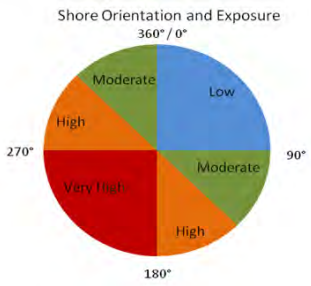
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 180 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 2 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 6

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 12

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 12

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-127	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.1** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **457** m

Depth (m): 9.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

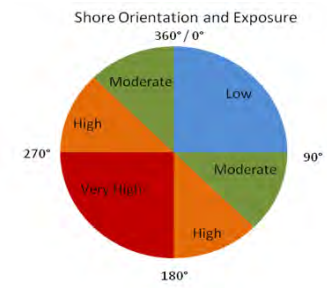
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **181** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **16**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **21**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRh-138	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: **3**

Fetch length (e.g., from Google Earth): **2.4** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **450** m

Depth (m): 16.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

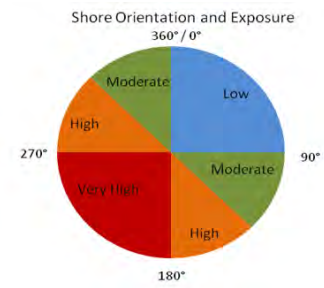
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **213** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **24**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **24**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRi-24	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **12.1** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **450** m

Depth (m): 16.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **3**

I-2 Terrain Exposure

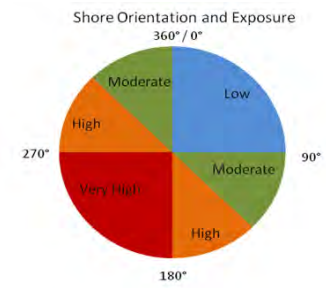
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **237** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **36**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **41**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **HIGH**

Site	HaRI-22	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3.7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 464 m

Depth (m): 2.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

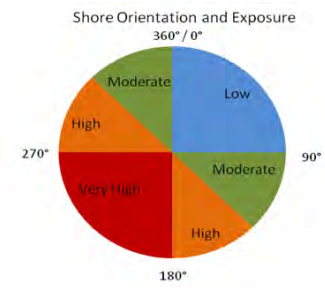
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 236 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 24

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 24

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRI-24	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3.8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro
Probable maximum flood elevation: 466.3 m
Elevation of site (e.g., based on LiDAR): 462 m
Depth (m): 4.3 m
Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

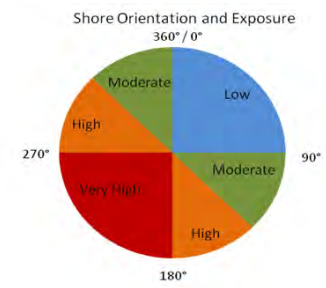
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 236 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 24

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 24

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-30	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 2

Fetch length (e.g., from Google Earth): 1.4 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 453 m

Depth (m): 13.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 1

I-2 Terrain Exposure

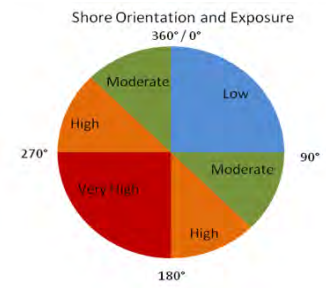
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 205 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	1	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 12

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 12

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-52	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: **3**

Fetch length (e.g., from Google Earth): **2.2** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **447** m

Depth (m): 19.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

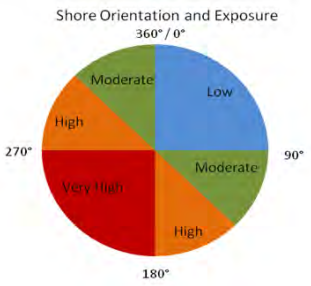
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **209** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **16**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **16**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HaRI-4	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 1

Fetch length (e.g., from Google Earth): 0.6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 464 m

Depth (m): 2.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 1

I-2 Terrain Exposure

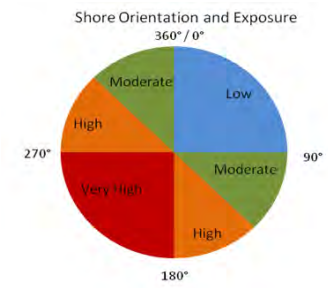
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 250 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	1	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient	Qualitative	Shallow	Moderate	Steep
	Measured Slope	< 5°	5° to 25°	> 25°
	Bedrock or Armoured	0	0	0
	Hard Till; Cobbles	-1	0	0
	Loose Till	-1	0	+1
	Loose Sands, Silts, Topsoil	-1	0	+1
	Organics	0	+1	+1
	Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 16

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 16

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRh-112

Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 464 m

Depth (m): 2.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

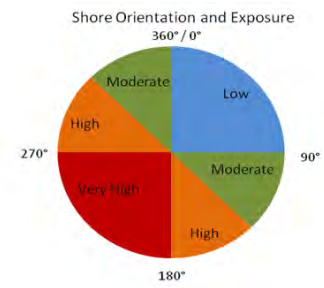
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 256 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 32

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRf-100	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 461 m

Depth (m): 5.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

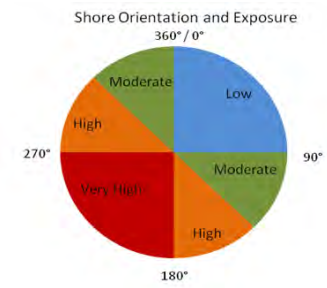
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	TRUE	FALSE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 1

Exposure to waves and currents: 90 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 1 *"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 12

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 12

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRi-60	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **12.5** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **456** m

Depth (m): 10.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **3**

I-2 Terrain Exposure

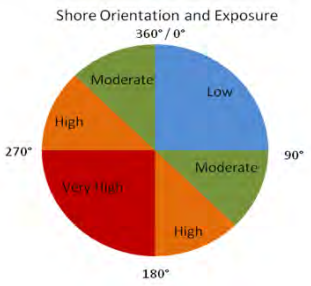
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **236** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **3** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **36**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **41**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **HIGH**

Site	HbRh-117

Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 464 m

Depth (m): 2.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

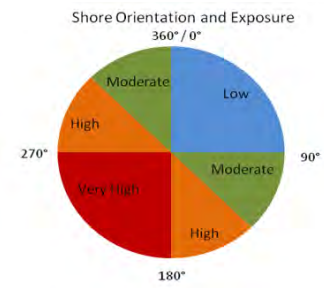
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 257 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 37

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HbRh-132	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.7** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **457** m

Depth (m): 9.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

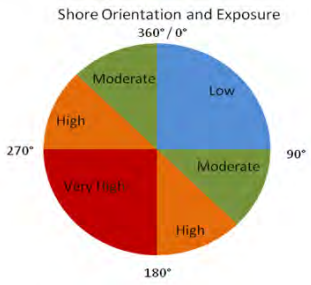
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **3**

Exposure to waves and currents: **141** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **2** *"Modified Fetch" from Step 3*

Exposure Score: **3** *"Exposure Score" from Step 4*

DRIVING FORCES: **6**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **12**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **12**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRh-135	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.4 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 450 m

Depth (m): 16.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

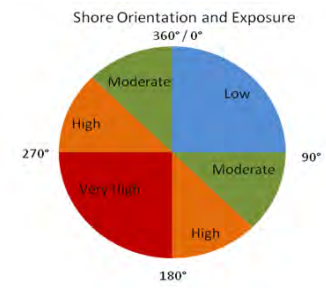
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 197 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	3	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Organics**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 36

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRk-48	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.8** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **466** m

Depth (m): 0.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

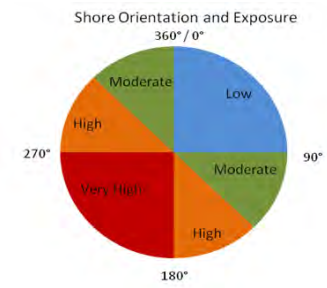
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **183** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **2** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **16**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **21**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HaRk-50	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.5 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 464 m

Depth (m): 2.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

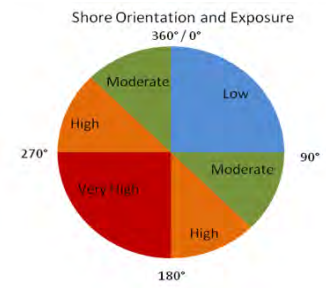
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 178 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 9

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 18

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 18

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRk-51	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 14 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 445 m

Depth (m): 21.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: -2

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

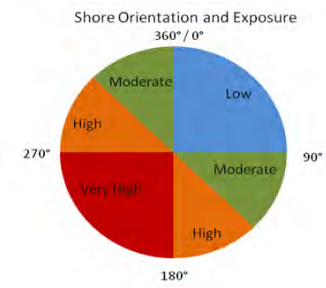
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	TRUE	FALSE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 1

Exposure to waves and currents: 52 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	2	*"Modified Fetch" from Step 3*	Exposure Score	1	*"Exposure Score" from Step 4*

DRIVING FORCES: 2

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 6

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 6

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRl-19	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.2 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 458 m

Depth (m): 8.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

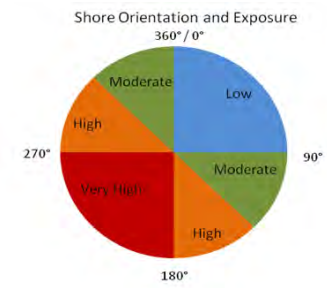
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 195 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 58

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRg-61	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **4.5** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **466** m

Depth (m): 0.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **4**

I-2 Terrain Exposure

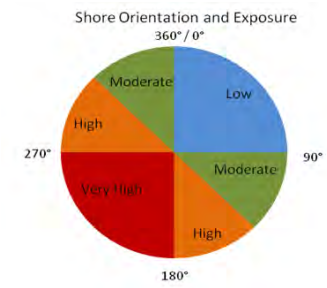
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **3**

Exposure to waves and currents: **296** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	4	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: **12**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **24**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **29**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **MODERATE**

Site	HbRh-114	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 8.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

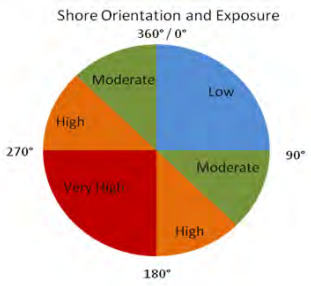
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 254 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 64

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 64

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

APPENDIX M-2
Site Specific E-PAST Results – Historical

APPENDIX M-2
Site Specific E-PAST Results
- Historical -

Site	Fetch Length (km)	Elevation of Site (m.amsl)	Exposure	Terrain Composition	Slope	Access	Score	Rating	Comments
'AMB-12-1'	11.8	457	236	< 5°	< 5°	potential access	37	MODERATE	At Attachie near outlet of Halfway River
'AMB-T1'	3.5	446	206	Loose Sands, Silts, Topsoil	5° to 25°	low access	12	LOW	On Bear Flats adjacent hwy 29
'AMB-T3'	7.9	455	244	Loose Sands, Silts, Topsoil	5° to 25°	low access	36	MODERATE	At apex of alluvial fan of relict Peace River tributary (gully feature)
'AMB-T4'	4.35	452	258	Loose Sands, Silts, Topsoil	< 5°	low access	24	LOW	On forested point bar feature of Peace River floodplain
'H-12-G13-1'	2.6	460	223	Loose Sands, Silts, Topsoil	< 5°	low access	24	LOW	Inundated in modern day Peace River by Hudson Hope
'H-12-G13-3'	2.6	461	230	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	46	HIGH	Right bank Peace River adjacent Hudson Hope on recreational property
'H-12-G13-3a'	2.7	460	220	Loose Sands, Silts, Topsoil	5° to 25°	known or apparent access	46	HIGH	Left bank Peace River at boat launch below Hudson Hope
'H-12-G13-4'	1.1	466	258	Loose Sands, Silts, Topsoil	< 5°	low access	16	LOW	Lower terrace on banks of Peace River tributary adjacent Hudson Hope
'H-12-G4'	11.8	460	236	Loose Sands, Silts, Topsoil	< 5°	potential access	37	MODERATE	At Attachie near outlet of Halfway River
'H-12-P1'	2.6	442	140	Loose Sands, Silts, Topsoil	< 5°	low access	6	LOW	Point bar deposit in Cache Ck
'HaRk-32'	1.25	456	196	Loose Sands, Silts, Topsoil	< 5°	potential access	13	LOW	Farrell Ck. Relict meander deposit
'HaRk-33'	0.7	456	160	Loose Sands, Silts, Topsoil	< 5°	potential access	5	LOW	Lower terrace adjacent hwy 29
'HaRk-34'	1.3	449	214	Loose Sands, Silts, Topsoil	< 5°	low access	12	LOW	Farrell Ck forested fan
'HaRk-38'	6	469	256	Loose Sands, Silts, Topsoil	< 5°	low access	32	MODERATE	Slope break betweeen bank of Peace River and mid-terrace
'HaRk-9'	3.3	468	205	Loose Sands, Silts, Topsoil	> 25°	low access	48	HIGH	Just upslope from modern day Peace River on forested floodplain
'HaRl-28'	1.05	465	246	Loose Sands, Silts, Topsoil	< 5°	potential access	21	LOW	Just upstream from Hudsons Hope on beach of the Peace River
'HaRl-4'	4.2	467	234	Loose Sands, Silts, Topsoil	5° to 25°	low access	48	HIGH	Righ bank adjacent Hudsons Hope
'HbRf-29'	3.8	416	329	Loose Sands, Silts, Topsoil	5° to 25°	low access	0	LOW	Outlet of Moberly River on right bank
'HbRf-31'	2.4	462	330	Loose Sands, Silts, Topsoil	< 5°	low access	12	LOW	Rocky Mtn Fort lower terrace
'HbRf-35'	7.3	436	263	Loose Sands, Silts, Topsoil	< 5°	low access	0	LOW	(HbRh-35) On modern day Peace river bank at edge of relect fluvial deposit
'HbRf-37'	2.2	416	298	Loose Sands, Silts, Topsoil	5° to 25°	low access	0	LOW	Lower terrace right bank of the Peace River
'HbRf-45'	3.8	424	315	Loose Sands, Silts, Topsoil	5° to 25°	low access	0	LOW	(HbRh-45) Right bank Peace River
'HbRf-8'	7.6	417	259	Loose Sands, Silts, Topsoil	> 25°	low access	0	LOW	Outlet of tributary gully feature, left bank Peace River
'HbRg-28'	6.3	468	306	Loose Sands, Silts, Topsoil	5° to 25°	potential access	41	HIGH	On transition from mid to upper terrace
'HbRi-10'	13	441	236	Loose Sands, Silts, Topsoil	< 5°	potential access	21	LOW	At Attachie near outlet of Halfway River
'HbRj-10'	5.9	439	240	Loose Sands, Silts, Topsoil	< 5°	low access	16	LOW	On relict fluvial terrace, right bank of the Peace Rv
'HbRj-6'	10.8	473	229	Loose Sands, Silts, Topsoil	5° to 25°	low access	48	HIGH	Left bank of the Peace River at outlet of tributary gully feature

Site	AMB-12-1	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 11.8 km

Step 2: Determine the Depth Modifier due to Depth at probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 457 m

Depth (m): 9.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

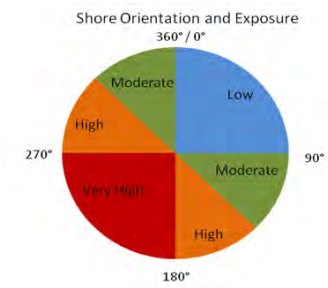
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 236 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 37

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	AMB-T1	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3.5 km

Step 2: Determine the Depth Modifier due to Depth at probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: -2

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 446 m

Depth (m): 20.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 1

I-2 Terrain Exposure

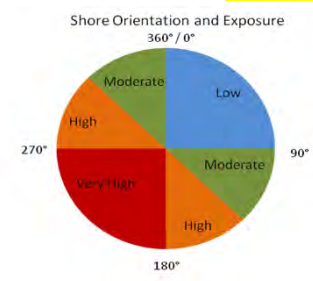
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 206 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	1	*"Modified Fetch" from Step 3*	Exposure Score	4	*"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 12

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 12

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	AMB-T3	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7.9 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 455 m

Depth (m): 11.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

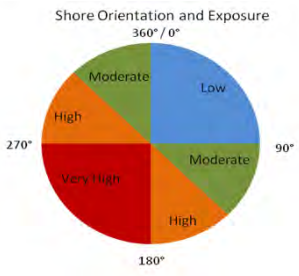
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 244 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **5° to 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 36

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	AMB-T4	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 4.35 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 452 m

Depth (m): 14.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

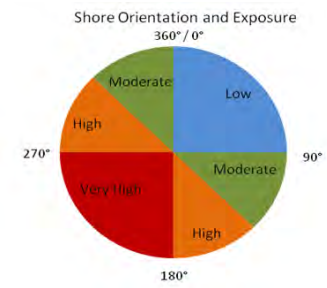
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 258 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 24

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 24

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	H-12-G13-1	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

I DRIVING FORCES

I-1 Fetch Length and Depth

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

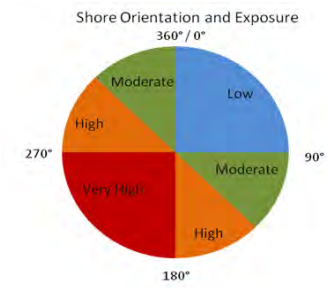
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 223 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 24

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 24

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	H-12-G13-3	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 461 m

Depth (m): 5.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

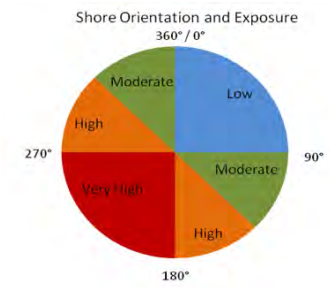
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 230 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 46

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	H-12-G13-3a	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.7 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

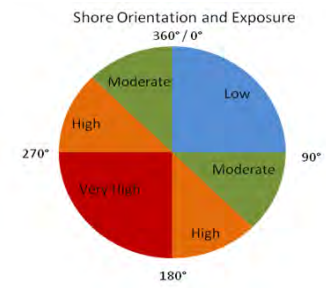
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 220 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 10

Human factor *(select from drop-down)*: **known or apparent access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 46

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	H-12-G13-4	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 2

Fetch length (e.g., from Google Earth): 1.1 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 466 m

Depth (m): 0.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 2

I-2 Terrain Exposure

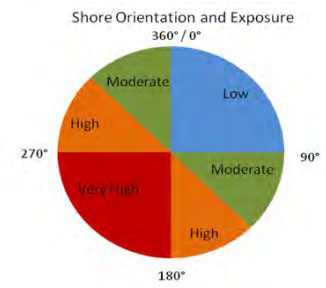
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 258 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 2 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 8

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 16

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 16

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	H-12-G4	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 11.8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 460 m

Depth (m): 6.3 m

Lowest level to be 460 m

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

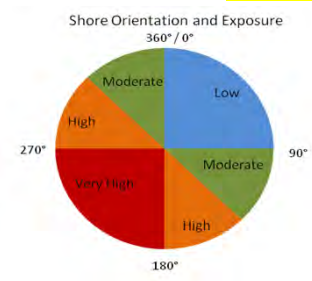
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 236 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **< 5°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 37

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	H-12-P1	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE
3

Fetch length (e.g., from Google Earth): 2.6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER
-2

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 442 m

Depth (m): 24.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE
1

I-2 Terrain Exposure

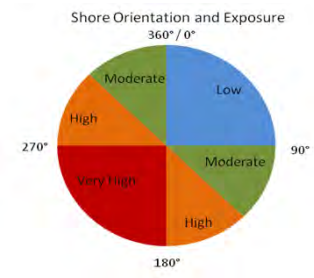
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE
3

Exposure to waves and currents: 140 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	1	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES
3

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE
3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER
-1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES
2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL
6

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL
0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE
6

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING
LOW

Site	HaRk-32	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 2

Fetch length (e.g., from Google Earth): 1.25 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 456 m

Depth (m): 10.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 1

I-2 Terrain Exposure

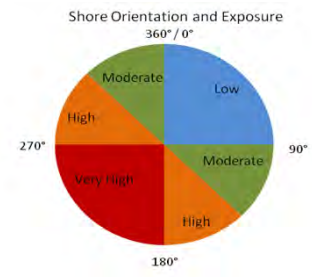
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 196 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 1 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the ground at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 8

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 13

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRk-33	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **1**

Fetch length (e.g., from Google Earth): **0.7** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: **-1**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **456** m

Depth (m): 10.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **0**

I-2 Terrain Exposure

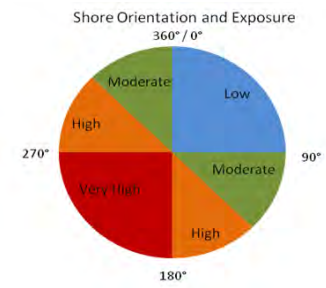
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **3**

Exposure to waves and currents: **160** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **0** *"Modified Fetch" from Step 3*

Exposure Score: **3** *"Exposure Score" from Step 4*

DRIVING FORCES: **0**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **0**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **5**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HaRk-34	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: 2

Fetch length (e.g., from Google Earth): 1.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	TRUE	FALSE	FALSE

DEPTH MODIFIER: -1

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 449 m

Depth (m): 17.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 1

I-2 Terrain Exposure

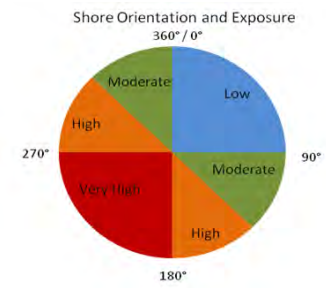
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 214 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 1 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 4

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 4

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 12

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 12

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HaRk-38	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 469 m

Depth (m): -2.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

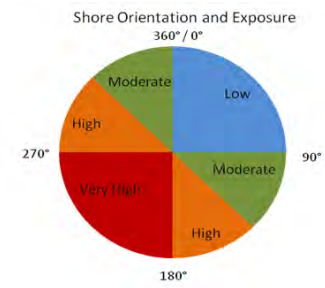
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 256 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 32

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 32

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: MODERATE

Site	HaRk-9	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 468 m

Depth (m): -1.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

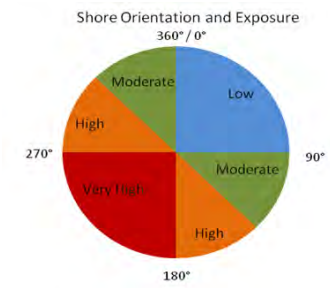
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 205 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 48

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HaRI-28	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

FETCH SCORE: **2**

Fetch length (e.g., from Google Earth): **1.05** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: **0**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **465** m

Depth (m): 1.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

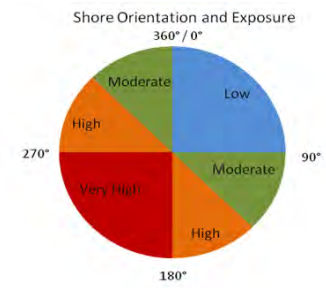
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **246** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **2** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **16**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **21**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HaRI-4	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): **4.2** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **467** m

Depth (m): -0.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

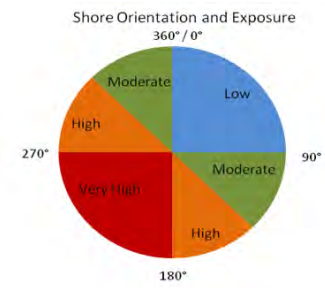
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: **234** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **4** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 48

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRf-29	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: **3**

Fetch length (e.g., from Google Earth): **3.8** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: **-4**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **416** m

Depth (m): 50.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **0**

I-2 Terrain Exposure

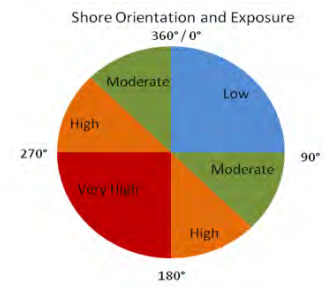
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	TRUE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **2**

Exposure to waves and currents: **329** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	2	*"Exposure Score" from Step 4*

DRIVING FORCES: **0**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **0**

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **3**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **0**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **0**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRf-31	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.4 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 462 m

Depth (m): 4.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 3

I-2 Terrain Exposure

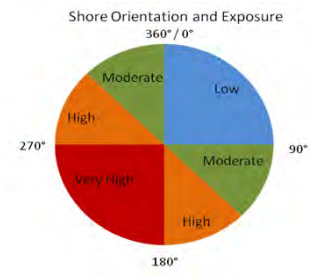
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	TRUE	FALSE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 2

Exposure to waves and currents: 330 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 3 *"Modified Fetch" from Step 3*

Exposure Score: 2 *"Exposure Score" from Step 4*

DRIVING FORCES: 6

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 12

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 12

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRf-35	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: -4

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 436 m

Depth (m): 30.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 0

I-2 Terrain Exposure

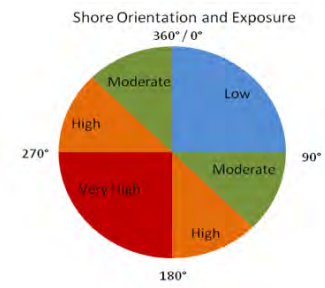
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 263 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 0 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 0

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: -1

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 2

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 0

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 0

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRf-37	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 2.2 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: -4

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 416 m

Depth (m): 50.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 0

I-2 Terrain Exposure

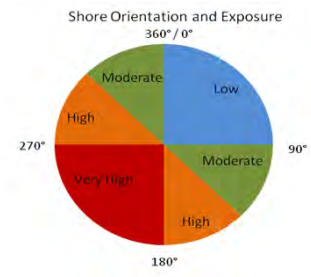
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 298 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score	0	*"Modified Fetch" from Step 3*	Exposure Score	3	*"Exposure Score" from Step 4*

DRIVING FORCES: 0

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 0

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 0

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRf-45	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

FETCH SCORE: 3

Fetch length (e.g., from Google Earth): 3.8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: -4

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 424 m

Depth (m): 42.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 0

I-2 Terrain Exposure

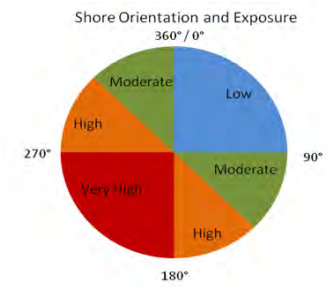
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 315 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 0 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 0

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 0

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 0

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRf-8	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 7.6 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	FALSE	TRUE

DEPTH MODIFIER: -4

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 417 m

Depth (m): 49.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 0

I-2 Terrain Exposure

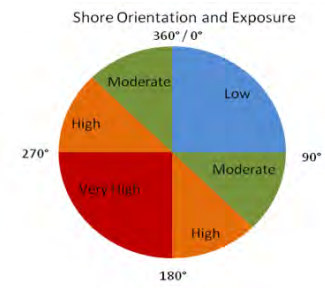
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 259 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 0 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 0

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: +1

Slope Gradient *(select from drop-down)*: **> 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 4

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 0

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 0

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: LOW

Site	HbRg-28	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 6.3 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 468 m

Depth (m): -1.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

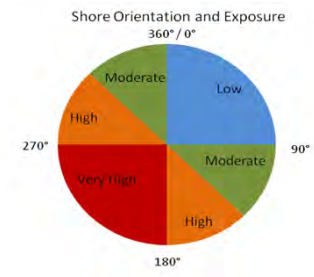
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	TRUE	FALSE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 3

Exposure to waves and currents: 306 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 3 *"Exposure Score" from Step 4*

DRIVING FORCES: 12

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient *(select from drop-down)*: **5° to 25°**

Slope Gradient: Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 36

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 5

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 41

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

Site	HbRi-10	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

I DRIVING FORCES

I-1 Fetch Length and Depth

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **13** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: **-2**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **441** m

Depth (m): 25.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

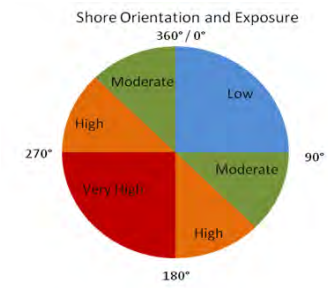
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **236** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **2** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **16**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **5**

Human factor *(select from drop-down)*: **potential access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **21**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRj-10	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces*Resisting Forces**

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: **4**

Fetch length (e.g., from Google Earth): **5.9** km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	FALSE	FALSE	TRUE	FALSE

DEPTH MODIFIER: **-2**

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): **439** m

Depth (m): 27.3 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: **2**

I-2 Terrain Exposure

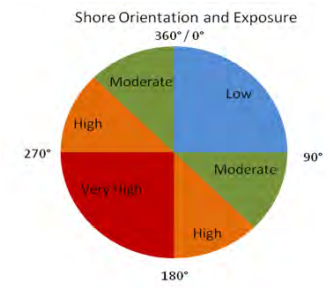
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: **4**

Exposure to waves and currents: **240** degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: **2** *"Modified Fetch" from Step 3*

Exposure Score: **4** *"Exposure Score" from Step 4*

DRIVING FORCES: **8**

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: **3**

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: **-1**

Slope Gradient *(select from drop-down)*: **< 5°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: **2**

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: **16**

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: **0**

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: **16**

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: **LOW**

Site	HbRj-6	Provide the Borden Number for the Site

This tool is based on: **Erosion** = **Driving Forces***Resisting Forces

INPUTS

Highlighted cells are required inputs (site-specific)

I DRIVING FORCES

I-1 Fetch Length and Depth

Change ONLY values in the YELLOW highlighted cells, either by typing in the correct number or selecting from the drop-down menu. In the Field, establish the scores and modifiers from the Tables given.

Step 1: Determine the **Fetch Score** by measuring the longest straight-line distance to the opposite shore of the reservoir from the site. The opposite shoreline is typically taken as being the longest straight-line distance which can be measured to the other side of the reservoir. This is commonly aligned with the slope aspect of the terrain but may be oriented at an angle if there is a longer clear line of site along the valley to the other side. The Fetch and Exposure are typically measured along the same line. Fetch considers ice and waves due to wind stress in ice sheets leading to rafting.

Fetch Length (km)	<0.5	0.5-1	1-2	2-4	4-16	16-48	>48
Base Score	0	1	2	3	4	5	6
Flag	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

FETCH SCORE: 4

Fetch length (e.g., from Google Earth): 10.8 km

Step 2: Determine the Depth Modifier due to Depth at Probable maximum flood for the site based on the elevation difference between the site and the proposed Probable maximum flood elevation. The Modifier is based on an understanding that deeper sites are less exposed to erosion than shallower sites.

Depth at Probable maximum flood (m)	0-10	10-20	20-30	> 30
Modifier	0	-1	-2	-4
Flag	TRUE	FALSE	FALSE	FALSE

DEPTH MODIFIER: 0

Elevation data from BC Hydro

Probable maximum flood elevation: 466.3 m

Elevation of site (e.g., based on LiDAR): 473 m

Depth (m): -6.7 m

Lowest level to be 460 m

Step 3: Determine the **Modified Fetch** Score and record it at **STEP 5** below**, numbers below 0 are treated as 0.**

Modified Fetch Score = Fetch Score + Depth Modifier

Record Modified Fetch Score at **Step 5** below

MODIFIED FETCH SCORE: 4

I-2 Terrain Exposure

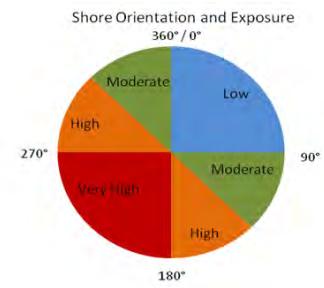
Step 4: Determine the **Exposure Score** by estimating the compass direction out into the reservoir from the site along the line of the Fetch (Step 1) and record it at **STEP 5** below.

Exposure	Very Low	Low	Moderate	High	Very High
Direction	Short <0.5 km long fetches	0° - 90°	90° - 135° and 315° - 360°	135° - 180° and 270° - 315°	180° - 270°
Base Score	0	1	2	3	4
Flag	FALSE	FALSE	FALSE	FALSE	TRUE

Based on wind rose for Fort St John Airport 1971-2000

EXPOSURE SCORE: 4

Exposure to waves and currents: 229 degrees



Step 5: Using the **Modified Fetch Score** (Step 3) and **Exposure Score** (Step 4), establish a value for the **DRIVING FORCES** of the terrain. The DRIVING FORCES value is the cross-product of the Modified Fetch and Exposure Scores (multiply them together).

Modified Fetch Score: 4 *"Modified Fetch" from Step 3*

Exposure Score: 4 *"Exposure Score" from Step 4*

DRIVING FORCES: 16

II RESISTING FORCES

II-1 Terrain Composition

Step 6: Determine the **Terrain Score** based on the materials **Type** and/or **Description** present at surface or by comparison with reference photos, if available.

Type	Bedrock or Armoured	Hard Till; Cobbles	Loose Till	Loose Sands, Silts, Topsoil	Organics	Loess
Description	man-made and boulder shores and riverbanks	does not break up easily with a shovel; cobbles	breaks up easily with a shovel	unconsolidated materials	marsh	dunes
Base Score	0	1	2	3	4	5

Based on typical surficial geology for NE BC

TERRAIN SCORE: 3

Terrain Composition *(select from drop-down)*: **Loose Sands, Silts, Topsoil**

Step 7: Determine the **Terrain Modifier** by ***Slope Gradient*** from available topographic profile data or from measurement in the field of the typical slope of the round at the site or select the steepest terrain crossing the identified site (i.e. a riverbank with exposed features in it).

Slope Gradient

Qualitative	Shallow	Moderate	Steep
Measured Slope	< 5°	5° to 25°	> 25°
Bedrock or Armoured	0	0	0
Hard Till; Cobbles	-1	0	0
Loose Till	-1	0	+1
Loose Sands, Silts, Topsoil	-1	0	+1
Organics	0	+1	+1
Loess	0	+1	+2

Slope Classes based on slope classes in: Resources Inventory Committee. 1995. BC Physical Shorezone Mapping System, v 1.0 Howes and Kenk. 1997. Terrain Classification System for BC, 2nd Ed.

TERRAIN MODIFIER: 0

Slope Gradient *(select from drop-down)*: **5° to 25°**

Step 8: Determine the value for the **RESISTING FORCES**.

RESISTING FORCES = Terrain Score (Step 6) + Terrain Modifier (Step 7)

RESISTING FORCES: 3

III EROSION POTENTIAL

III-1 Erosion Potential

Step 9: Multiply the **DRIVING FORCES** from Step 5 by the **RESISTING FORCES** (Step 8) to determine the NATURAL POTENTIAL.

NATURAL POTENTIAL = Driving Forces score (Step 5) times Resisting Forces score 3 (Step 8)

NATURAL POTENTIAL: 48

Step 10: Determine the **HUMAN POTENTIAL** for erosion.

No evidence of, or unlikely to have, human interaction with site	0	low access
Evidence of foot or animal traffic (e.g., hoofmarks) or near public access	5	potential access
Evidence of vehicle access to site	10	known or apparent access

HUMAN POTENTIAL: 0

Human factor *(select from drop-down)*: **low access**

III-2 Erosion Potential Score

Step 11: Modify the **NATURAL POTENTIAL** (Step 9) by the **HUMAN POTENTIAL** (Step 10) to determine the EROSION POTENTIAL SCORE

EROSION POTENTIAL SCORE = NATURAL POTENTIAL (Step 9) plus HUMAN POTENTIAL (Step 10)

EROSION POTENTIAL SCORE: 48

Give the site a Susceptibility Rating of either Low, Moderate or High erosion potential based on the EROSION POTENTIAL SCORE

Final Score	<25	25 to 40	>40
Rating	Low	Moderate	High

SUSCEPTIBILITY RATING: HIGH

APPENDIX N

Photographs

Appendix N-1 – Palaeontology Photographs

Appendix N-2 – Archaeology Photographs

Appendix N-3 – Historical Photographs

Photograph 1: Steep face at PS067D that exposes Moosebar Fm shales, siltstones, and sandstones with capping Quaternary gravels

Photograph 2: The location of dinosaur footprints unearthed at the W.A.C. Bennett Dam in 2012. (Photo Credit: Dan Bouillon, BC Hydro)

Photograph 3: Large theropod dinosaur foot impressions preserved in a rippled sandstone bed of the Gates Fm, unearthed at the W.A.C. Bennett Dam during maintenance in 2012 (Photo Credit: Dan Bouillon)

Photograph 4: View of PS001A and (fish scale fossils) showing draped colluvium of lacustrine sediments and the Shaftesbury Fm

Photograph 5: Fish scales from the Upper Shaftesbury Fm found in a road cut at a switchback on the south bank of the Peace River, downstream from the confluence in the Moberly River at PS124D

Photograph 6: Ctenoid fish scales from the Upper Shaftesbury Fm in PS001C, located on the north side of the Peace River, downstream from the confluence with the Moberly River

Photograph 7: A palaeosol in Quaternary sediments at PS001C, located in a coulee on the north bank of the Peace River downstream from the confluence with the Moberly River

Photograph 8: A large narrow concretion consistent with the size and shape of a large rapidoplacenticerid ammonite. This concretion is within the Upper Shaftesbury Fm in PS004A, along the northeast bank of the Peace River downstream of Tea Creek

Photograph 9: A neogastroplitid ammonite from the corner of an in situ tabular concretion from the Upper Shaftesbury Fm at PS004A located along the northeast bank of the Peace River, downstream of Tea Creek

Photograph 10: A partial beudanticerid ammonite displaying the typical contorted sutural pattern from the Upper Shaftesbury Fm in PS004A along the northeast bank of the Peace River, downstream of Tea Creek

Photograph 11: Low exposure of Shaftebury Fm shales overlain by thick Quaternary sands and gravels in PS005B, near the mouth of Tea Creek

Photograph 12: Fossil fish scales at PS006C from thinly bedded siltstone from the Upper Shaftesbury Fm, located along the Peace River upstream from the confluence with Tea Creek.

Photograph 13: View of PS012A-C showing ammonite rapidoplacenticeras sp. cf R. sutherlandbrowni. The fossil is situated in a concretion from the Upper Shaftesbury Fm within the Wilder Creek coulee

Photograph 14: A neogastroplitid ammonite contained in a concretion from the Shaftesbury Fm at PS012H, located along Wilder Creek

Photograph 15: A partial rapidoplacenticerid ammonite with septarian cracks from the Upper Shaftesbury Fm shales in PS013D, along Wilder Creek

Photograph 16: A large inoceramid clam encrusted with an ironstone rind from the Upper Shaftesbury Fm. This fossil was found at PS005D along Wilder Creek

Photograph 17: A dislodged block of Quaternary palaeosol with charcoal fragments from PS005D, located west of the confluence of Tea Creek with the Peace River

Photograph 18: A rapidoplacenticerid ammonite in a septarian concretion from the Upper Shaftesbury Fm at PS013E along Wilder Creek

Photograph 19: A fossilscape in ironstone from along Wilder Creek (PS013F) exhibiting juvenile ammonites, pelecypods, and cycad pinnules from the Upper Shaftesbury Fm

Photograph 20: Twin juvenile neogastroplitid ammonites from Upper Shaftesbury Fm shales in PS013F, along Wilder Creek

Photograph 21: View of an inoceramid clam (?Cremnoceramus) from the Upper Shaftesbury Fm at PS015A, located along the Peace River upstream from the confluence with Wilder Creek

Photograph 22: View along the Peace River of "Ammonite Beach", located upstream from the confluence with Wilder Creek. This location corresponds to PS021E-F

Photograph 23: Fossilscape from PS023A with adult and juvenile inoceramid clams in ironstone from the middle terrace of the Peace River on southeast Bear Flat

Photograph 24: A partial inoceramid or possibly a pen clam (Pinna sp.) along upper Cache Creek just above the confluence with Red Creek, within the Upper Shaftesbury Fm at PS023A

Photograph 25: Fossilscape in sandstone with gastropods, inoceramid and small clams, conifer needles and cyad pinnules from PS025B along Cache Creek

Photograph 26: Broad cycad pinnules from PS025E along Cache Creek in the upper Shaftesbury

Photograph 27: Juvenile neogastroplitid ammonites from the Shaftesbury Fm in PS025E along Cache Creek

Photograph 28: An extensive exposure of highly fossiliferous Shaftesbury Fm at PS026C along Cache Creek, downstream from Red Creek

Photograph 29: A partial cycad crown of rachis from the Shaftesbury Fm at PS026C along Cache Creek, downstream from Red Creek

Photograph 30: A very large inoceramid clam found at PS026C in a concretion from the Shaftesbury Fm along Cache Creek, downstream from Red Creek

Photograph 31: A large neogastroplitid ammonite from the Shaftesbury Fm at PS026C along Cache Creek

Photograph 32: The bark and cast of a cycad tree trunk from the Shaftesbury Fm in PS026C along Cache Creek

Photograph 33: Fossilscape showing scraping tracks produced by a three-toed reptile (e.g., a turtle), from the Shaftesbury Fm at PS026C along Cache Creek

Photograph 34: A neogastroplitid ammonite in a concretion from the Shaftesbury Fm in PS026C along Cache Creek

Photograph 35: A juvenile inoceramid clam from the Upper Shaftesbury Fm at PS026D, located along Cache Creek

Photograph 36: A concretion yielding bivalves and ammonites from PS026F along Cache Creek

Photograph 37: A small exposure high on the right bank of Cache Creek at PS026F showing the Shaftesbury Fm with fossiliferous concretions capped by Quaternary gravels and sands

Photograph 38: View of an exposure along Cache Creek at PS026G showing upper Shaftesbury Fm shales with ironstone and concretions protruding; Quaternary sands overlay the bedrock

Photograph 39: A partial large inoceramid clam in an ironstone block from the Upper Shaftesbury Fm at PS026G along Cache Creek

Photograph 40: Three juvenile inoceramid shell casts in an ironstone slab from the Upper Shaftesbury Fm at PS027A along Red Creek near the confluence with Cache Creek

Photograph 41: An extensive natural pavement of fractured fossiliferous ironstone in PS027G along Red Creek

Photograph 42: Dr. Edward Davies on a small exposure of the Shaftesbury Fm with numerous fossiliferous concretions protruding out in PS027G, along Red Creek

Photograph 43: A partial large cycad pinnule in a concretion from the Upper Shaftesbury Fm at PS027J, located along Red Creek

Photograph 44: A clam (Unio? sp.) from the Upper Shaftesbury Fm in PS027K along Red Creek

Photograph 45: An ironstone bed with mud cracked having ammonites, gastropods and pelecypods observed in PS027K, in the upper Shaftesbury Fm

Photograph 46: Cycad pinnules on an ironstone slab within PS028A along upper Cache Creek just upstream from the confluence with Red Creek

Photograph 47: Multiple neogastroplytid ammonites from concretions in PS028A along upper Cache Creek just upstream from the confluence with Red Creek

Photograph 48: A neogastroplitid ammonite in an ironstone slab dislodged from the Shaftesbury Fm in PS028A, along Cache Creek, upstream from Red Creek

Photograph 49: A fossilscape in ironstone with multiple juvenile inoceramid clams and neogastroplitid ammonites found at PS028B in the Upper Shaftesbury Fm along upper Cache Creek, just upstream of the confluence with Red Creek

Photograph 50: A cycad crown of multiple rachis (leaf stems) from PS028B, located along Cache Creek just upstream from the confluence with Red Creek

Photograph 51: A steep face in PS028B exposing Upper Shaftesbury Fm shales with multiple concretions protruding out above Cache Creek, just upstream from the confluence with Red Creek

Photograph 52: Impression of podocarpidaceous tree bark from the Shaftesbury Fm in PS028B along Cache Creek

Photograph 53: A fossilscape with ammonites, inoceramids, and cycad pinnules from the Shaftesbury Fm in PS029A, along Cache Creek

Photograph 54: A "pestle and mortar" which could be a sea anemone trace fossil in an ironstone slab from the Upper Shaftesbury Fm in PS029B, along Cache Creek

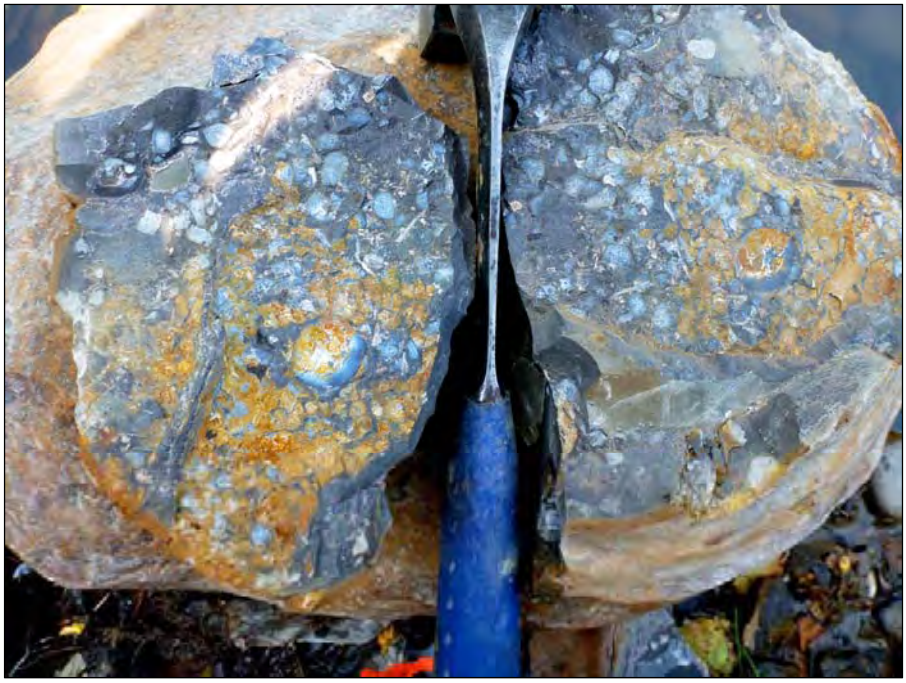
Photograph 55: Rapidoplacenticeras ammonite found at PS029B in a concretion from the Upper Shaftesbury Fm along Cache Creek

Photograph 56: Cycad rachis in an upper Shaftesbury Fm ironstone slab at PS029B along the upper reaches of Cache Creek

Photograph 57: Cycad pinnules from the Shaftesbury Fm found in PS029B, along Cache Creek

Photograph 58: A loosely coiled neogastroplitid ammonite in a concretion from the Upper Shaftesbury Fm, found at PS029C along Upper Cache Creek

Photograph 59: Extensive Shaftesbury Fm shale exposures with abundant fossiliferous concretions and ironstones in PS029D, located along the left bank of Cache Creek



Photograph 60: A fossiliferous concretion with inoceramid clam shell echinoderms and fish elements from the Shaftesbury Fm in PS029E, along Cache Creek

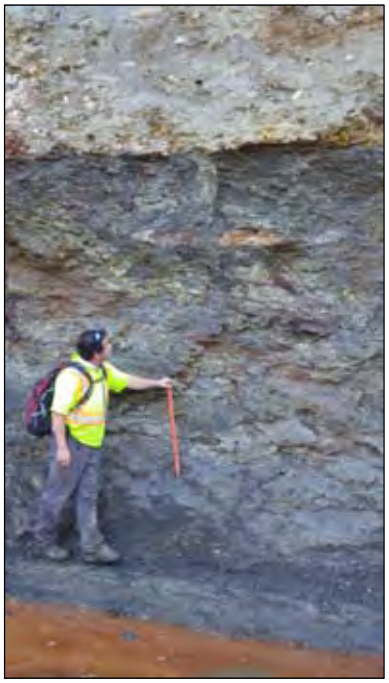
Photograph 61: Neogastroplitid ammonite in a concretion from Shaftesbury Fm shales in PS029E, along Cache Creek

Photograph 62: Palaeontology crew reviewing a low exposure of Upper Shaftesbury Fm bedrock, hidden from aerial view, located along the south bank of Cache Creek at new PS029E/F

Photograph 63: Monocotyledonous - reed-like plant leaves from the Shaftesbury Fm in new PS029B, located along Cache Creek

Photograph 64: Photograph 109: Several neogastroplitid ammonites in a dislodged ironstone slab in the Cache Creek stream bed near the end of the reach at PS029G

Photograph 65: Rapidoplacenticeras ammonite in a concretion from the Upper Shaftesbury Fm in PSX07A along Red Creek



Photograph 66: Outcrop at PSX07A, in the Upper Shaftesbury Fm along Cache Creek

Photograph 67: Shaftesbury Fm shales in PSX07A with corroded concretions and draped with a fine talus at the upper reach of Red Creek

Photograph 68: Two ammonites, a neogastroplitid and juvenile rapidoplacenticerid, from the Upper Shaftesbury Fm in PSX07B along Red Creek

Photograph 69: A bird bone (metatarsal) from the Quaternary sands deposited on the middle terrace bluffs along southwest Bear Flat at PS037B

Photograph 70: View of an algal frond, found free of any concretion at PS040D, in the Lower Shaftesbury Fm along the Halfway River near the Highway 29 bridge

Photograph 71: View of PS047B showing the Shaftesbury Fm with abundant colluvium covering the slopes with overlying Quaternary sands and gravels, forming hoodoos

Photograph 72: Hoodoos perched on the edge of terrace along the west "camel hump" meander of the Halfway River, at PS047B

Photograph 73: View of Corbulid bivalves found at PS048B along the Halfway River in dislodged sandstone blocks that fell from above the find spot

Photograph 74: View of Scallop-like bivalve (?Camptonectes sp.) and Corbulid bivalve bed found at PS048B along the Halfway River in dislodged sandstone blocks that fell from above the find spot

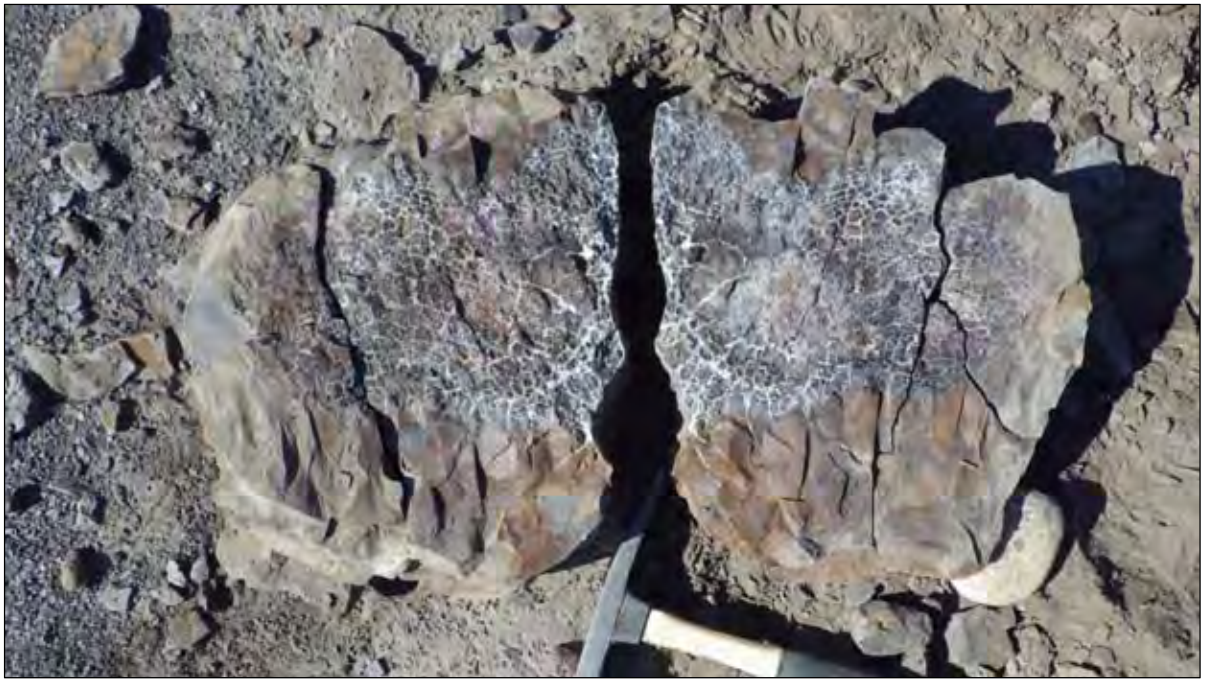
Photograph 75: Transverse planar view of an algal frond found at PS049B. This view shows several blades and stypes (note the white sectarian infilling) found in a concretion along the Halfway River

Figure 76: View upstream of the fossiliferous Shaftesbury Fm situated along the Halfway River. This location is overlain by slumping Quaternary colluvium and sands. This location corresponds with PS049B-C and contains abundant concretions with algal fronds, a large fossil log, and pelecypods

Photograph 77: View of a 2 m long petrified fossil log from the Lower Shaftesbury Fm at PS049B on the Halfway River

Photograph 78: The podocarpaceous Nageiopsis cf. N. anglica at PS050A showing elongate multiple fronds with flat pinnules and rounded apices, attached alternating on a thin but robust rachis

Photograph 79: View along the Halfway River of PS051B which has abundant algal fronds in concretions from the Lower Shaftesbury Fm



Photograph 80: Algal frond in an ironstone bed in the Lower Shaftesbury Fm (Hulcross Fm) from PSX09E located near the edge of the LAA on the Halfway River

Photograph 81: Theropod teeth imbedded in an ironstone matrix in the Lower Shaftesbury Fm (Hulcross Fm) located near the edge of the LAA on the Halfway River at PSX09G

Photograph 82: Helminthopsis worm burrows densely packed into ironstone from the Lower Shaftesbury Fm (Hulcross Fm) from PSX09G, located near the edge of the LAA on the Halfway River

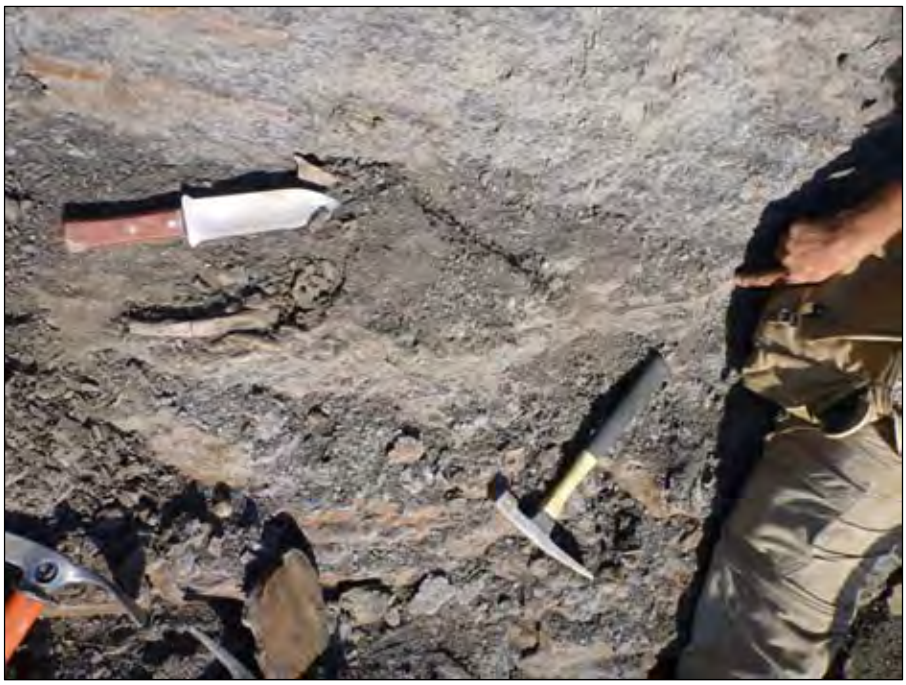
Photograph 83: An algal frond cross section in a concretion in the Lower Shaftesbury Fm (Hulcross Fm) in PSX09G, located near the edge of the LAA on the Halfway River

Photograph 84: Dinosaur bones in a concretion along a narrow ledge in PSX09Z, found at the base of the exposure of the Lower Shaftesbury Fm (Hulcross Fm) located near the edge of the LAA on the Halfway River

Photograph 85: Dinosaur bones in situ along the narrow ledge at the base of the exposure of the Lower Shaftesbury Fm (Hulcross Fm) in PSX09Z, located near the edge of the LAA on the Halfway River

Photograph 86: Concretion extracted from PSX09Z that contains dinosaur bones. The concretion is from the Lower Shaftesbury Fm (Hulcross Fm), found along a narrow ledge at the base of an exposure located near the edge of the LAA on the Halfway River

Photograph 87: A partial dinosaur scapula recovered from the base of the exposure of the Lower Shaftesbury Fm (Hulcross Fm) in PSX09Z located near the edge of the LAA on the Halfway River



Photograph 88: A small boned dinosaur skeleton protruding from the Hulcross Fm siltstones and ironstones found beyond the edge of the LAA along the Halfway River in PSX09Z. Remains are traceable from the fingertip (right) to the knife handle (left)

Photograph 89: Ossified tendon probably derived from a dinosaur found just beyond the LAA along the Halfway River in PSX09Z

Photograph 90: View of a large cycad leaf structure, with possibly affinities to Ctenis, from PS056B, in a concretion in the Lower Shaftesbury Fm along the Halfway River

Photograph 91: A crown of cycad rachis in sandstone from the Shaftesbury Fm in PS061B, located along the northwest bank of the Peace River between the Halfway River and Farrell Creek

Photograph 92: Fossil roots in the Shaftesbury Fm from PS061B along the north bank of the Peace River between the Halfway River and Farrell Creek

Photograph 93: A pair of gastropod shells (Discus whiteyi) from the Quaternary sands deposited on the lower terrace bluffs at the mouth of Farrell Creek in PS062A

Photograph 94: A rodent (Vole) lower mandible from Quaternary sands deposited on the lower terrace bluffs at the mouth of Farrell Creek in PS062A

Photograph 95: Fossil gastropods lodged in travertine found in PS062B near the confluence of Farrell Creek with the Peace River

Photograph 96: View of steep cliff faces at PS062D showing the exposed Lower Shaftesbury Fm and Hulcross Fm along Farrell Creek

Photograph 97: Inoceramid clam cast found at water level in the Hulcross Fm along Farrell Creek within PS062E

Photograph 98: A pair of juvenile ammonites from the Hulcross Fm found at PS062M/N, north of the Highway 29 Bridge at Farrell Creek

Photograph 99: View of an exposed section of fossiliferous Hulcross Fm in PS062M/N on the right bank of Farrell Creek north of the Highway 29 bridge

Photograph 100: A fossil jellyfish imprint in the Hulcross (lower Shaftesbury) Fm at PS063A, on the northwest bank of the Peace River at the confluence of Farrell Creek

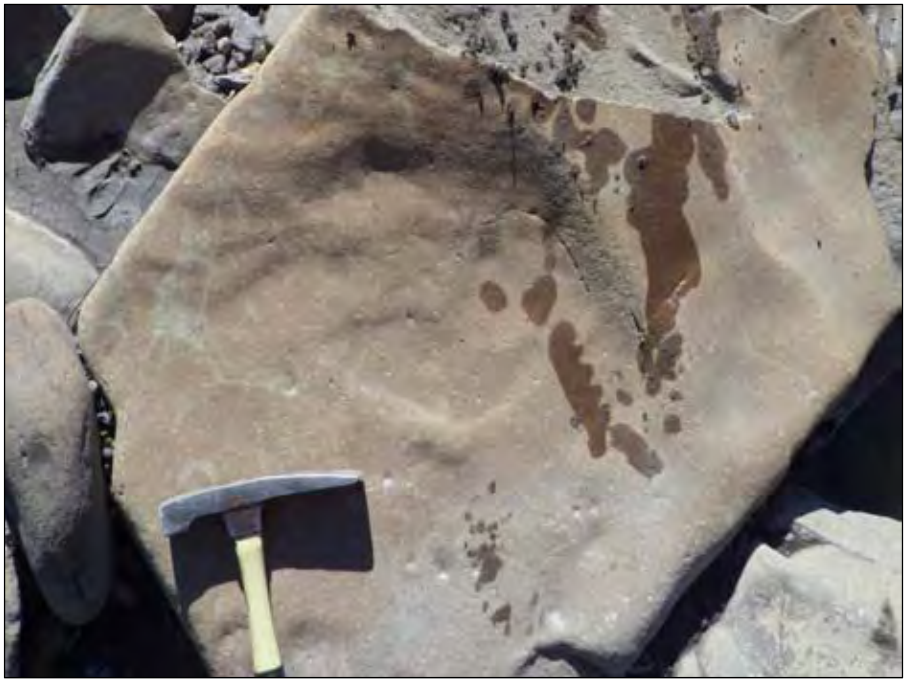
Photograph 101: James Soriano examining the Lower Shaftesbury Fm (Hulcross Fm) sediments in a large cathedral-like gully north of Gates Island on the Peace River in PS064C

Photograph 102: Roots of a fossil aquatic fern called a quillwort of the Genus Isoetites from the Gates Fm on the northwest shore of the Peace River, west of Gates Island in PS065A

Photograph 103: Monocotyledon Form B: broad-leaf form, appears as a rosette around a stem. This fossil was found in the Gates Fm in PS065A

Photograph 104: Cycad pinnules and monocot leaf strewn on a Gates Fm sandstone slab found at PS067A along Lynx Creek

Photograph 105: The heel print of a theropod dinosaur in a Gates Fm sandstone block found at PS067A along Lynx Creek, just north of Highway 29



Photograph 106: A possible dinosaur track in a Gates Fm rippled sandstone block at PS067A along Lynx Creek, just north of Highway 29

Photograph 107: A reworked ammonite occurring as a cobble in gravels along Lynx Creek at PSX13B

Photograph 108: View of PSA069A-C showing modern travertine deposits below Hudson's Hope on the north bank of the Peace River

Photograph 109: Rudist pelecypods from the Moosebar Fm found at PS069D, upstream along the Peace River from Hudson's Hope

Photograph 110: Pelecypod cast and mould from the Moosebar Fm found at PS069D, upstream along the Peace River from Hudson's Hope

Photograph 111: An ammonite (Archtoplites sp.) from the Moosebar Fm in PS069D, located along the northwest bank of the Peace River southwest of Hudson's Hope

Photograph 112: View of PS070A showing Gates Fm sandstones on a rocky island, downstream from Alwin Holland Park on the Peace River

Photograph 113: View of trace fossil Asterocites showing two starfish resting places and connecting movement traces on a bedding surface of Gates Fm sandstone. This trace fossil was found in PS070A, located downstream from Alwin Holland Park on the Peace River

Photograph 114: View of PS070A showing abundant load casts, possibly comprising many dinosaur footprints one on top of the other (e.g., dinoturbulated) or flow rolls from the Gates Fm, this site is located downstream from Alwin Holland along the Peace River

Photograph 115: Cycad pinnule and wood fragments at (PS070A) in the Gates Fm, downstream from Alwin Holland Park on the Peace River

Photograph 116: View along the banks of the Peace River at PS070B showing the steep face exposing Moosebar Fm siltstones and shales with capping Quaternary travertine containing large gastropods

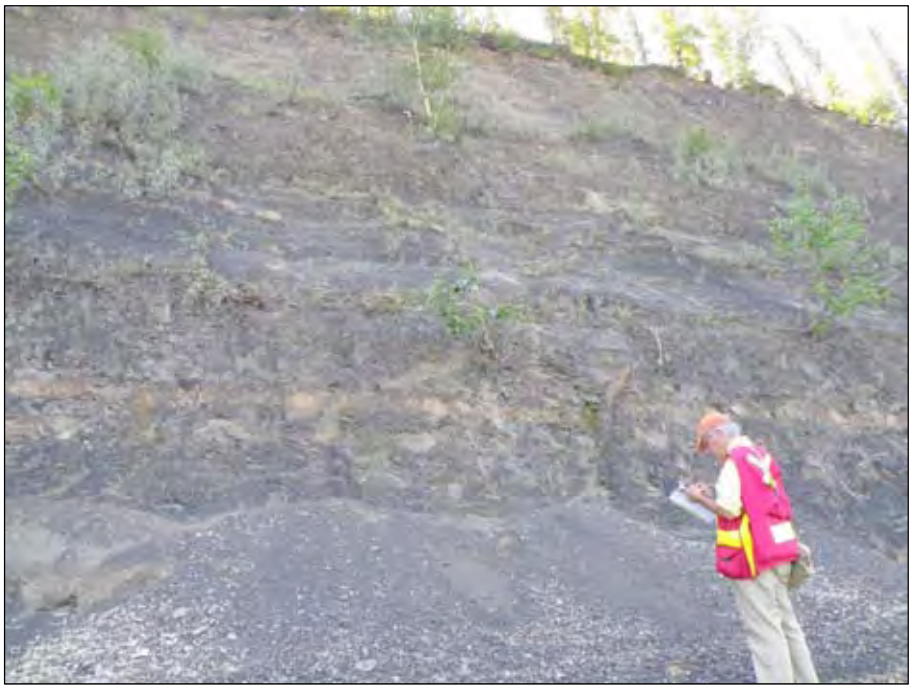
Photograph 117: Several gastropods recovered from Quaternary sediments in PS70B, located along the northwest bank of the Peace River, southwest of Hudson's Hope

Photograph 118: A small branch of a monkey puzzle tree (Araucariaceae) from Moosebar Fm in PS070C, located along the northwest bank of the Peace River, southwest of Hudson's Hope

Photograph 119: View of trace fossils from Planolites sp. showing semi-horizontal burrows, at in PS072B

Photograph 120: Dinosaur track possibly from ?Tetrapodosaurus in rippled sandstone near the Highway 29 Peace Canyon bridge at PS072B

Photograph 121: Fossil log possibly from a podocarpaceous tree with affinities to Nageia or Phyllocladus, at PS072B



Photograph 122: View of PS073B showing the Moosebar Fm with alternating shales, silts, and ironstone beds

Photograph 123: View of the trace fossil Conichnus sp. comprising a large conical burrow, possibly produced from a sea anemone found in PS073B

Photograph 124: View of a trace fossil, Rosselia choniodes, found in PS073B showing a deep, straight cylinder with larger upper cavity, possibly a crustacean burrow

Photograph 125: Long strap-like cycad rachis and pinnules from PS073B. The fossils are from the Gates Fm and were found along the southeast bank of the Peace River

Photograph 126: View of PS073F, which is located on a rocky island across from Alwin Holland Park. The site has casts of possible Amblydactylus dinosaur tracks in cross-section showing deformed shales around load cast and truncated by the flat overlying bed

Photograph 127: Dislodged digit cast of an Amblydactylus track found lying beside a larger load cast (Photograph 128) showing the 'dinoturbulated' strata. This trace fossil was found in PS073F, which is located on a rocky island across from Alwin Holland Park

Photograph 128: Cast of Amblydactylus track, probably the remaining portion to the dislodged digit cast (Photograph 127) also shown is the 'dinoturbulated' strata at PS073F

Photograph 129: View of under prints forming a possible dinosaur track way at PS073F which are located on a rocky island across from Alwin Holland Park

Photograph 130: View of an ammonite, Arcthoplites, from an amateur fossil collecting quarry site that corresponds to PS073I

Photograph 131: A partially buried Quaternary stump on a low island terrace between Hudson's Hope and Lynx Creek, at PS076E

Photograph 132: View of a poplar leaf mould found in a fragment of travertine, found in PS076E on the upstream gravel bank of an interfluvial island between Hudson's Hope and Lynx Creek

Photograph 133: A lily-like plant ?Lilites sp. showing multiple leaf blades radiating out in a rosette. This fossil is from the palaeontological "type-site" of the Gates Fm which is located adjacent to Gates Island in PS079A

Photograph 134: View of PS079E-G showing the Gates Fm sandstones with potential dinoturbulated layers near top on the upstream end of Gates Island

Photograph 135: View of a trace fossil representing a crustacean burrow from the Gates Fm. The trace fossil was identified in PS079E on the west shore of Gates Island

Photograph 136: Fossil horsetail fern (Equisetites sp.) sporophyte with a branching ribbed stem and a whorl of small leaves at nodes, and also trace fossils consisting of Diplocraterion burrows found at PS079E

Photograph 137: View of trace fossil Thalassinoides sp. B, a crustacean burrow with coarse grained pelloidal lining from the Gates Fm, at PS079G

Photograph 138: A starfish (Mediaster? sp.) found at PS084A within a small concretion from the Shaftesbury Fm in a small coulee cut into the south bank of the Peace River between the Halfway River and Farrell Creek

Photograph 139: Zamiaceaen cycad plant fossils with affinities to Ctenis and Podozamites showing the strong axis with a widely spaced whorl of sclerophyllic leaf petioles from the Shaftesbury Fm at PS090A on the south side of the Peace River across from the confluence with the Halfway River

Photograph 140: View of PS093B in the Middle Shaftesbury Fm, located along the south shore of the Peace River upstream from the confluence with the Halfway River

Photograph 141: A charcoaled log in a Quaternary gravel terrace above the Shaftesbury Fm along the south side of the Peace River upstream from Cache Creek, at PS099C

Photograph 142: View of an algal mat centered in a septarian mud concretion from the Shaftesbury Fm. This fossil was found at PS101A-E along the Peace River, across from the confluence of Cache Creek

Photograph 143: Zamitacean pinnule with Ctenis or Podozamites affinity in the Shaftesbury Fm along the south side of the Peace River upstream from Cache Creek, at PS101A

Photograph 144: View of an opened ammonite (Neogastroplites cornutus cornutus) concretion from the Shaftesbury Fm found at PS110E

Photograph 145: Tubular sponge of the Order Haplosclerida found at PS111A

Photograph 146: A partial cycad frond of pinnules from the Shaftesbury Fm in PS111B along a secondary channel on the south bank of the Peace River, upstream from the confluence of Tea Creek

Photograph 147: Fossil fish scales from the upper Shaftesbury Fm found along southeast bank of the Moberly River at PS114E

Photograph 148: Fossil gastropods eroding from glaciolaclustrine sediments found at PS116E located along the high southeast terrace edge of the Moberly River, near the confluence with the Peace River

Photograph 149: View along the Moberly River of PS117G which revealed a concretion containing Neogastroplites cornutus wilderensis in the Shaftesbury Fm

Photograph 150: A partial ammonite in the corner of a large concretion protruding from the Upper Shaftesbury Fm at PS119C, along the Moberly River

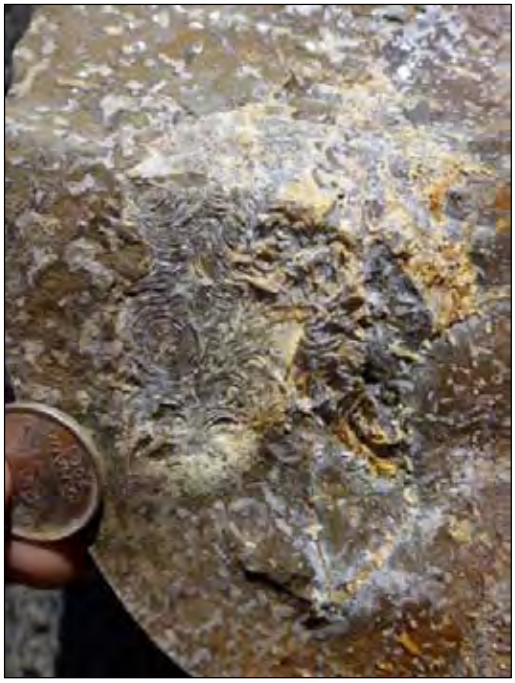
Photograph 151: Large (70 cm) Rapidoplacenticeras ammonite from PS119D, dislodged from the Upper Shaftesbury Fm along the Moberly River

Photograph 152: A neogastroplitid ammonite in a concretion from the Shaftesbury Fm found at PS119D along the Moberly River

Photograph 153: Limpet borings into a Rapidoplacenticeras ammonite in a concretion from the Upper Shaftesbury Fm at PS121D along the Moberly River

Photograph 154: View of an exposure at PSA121D showing the fossiliferous Upper Shaftesbury Fm along a back channel of the Moberly River

Photograph 155: Broad cycad leaf of Zamites from the Upper Shaftesbury Fm at PS121D, located along a back channel of the Moberly River

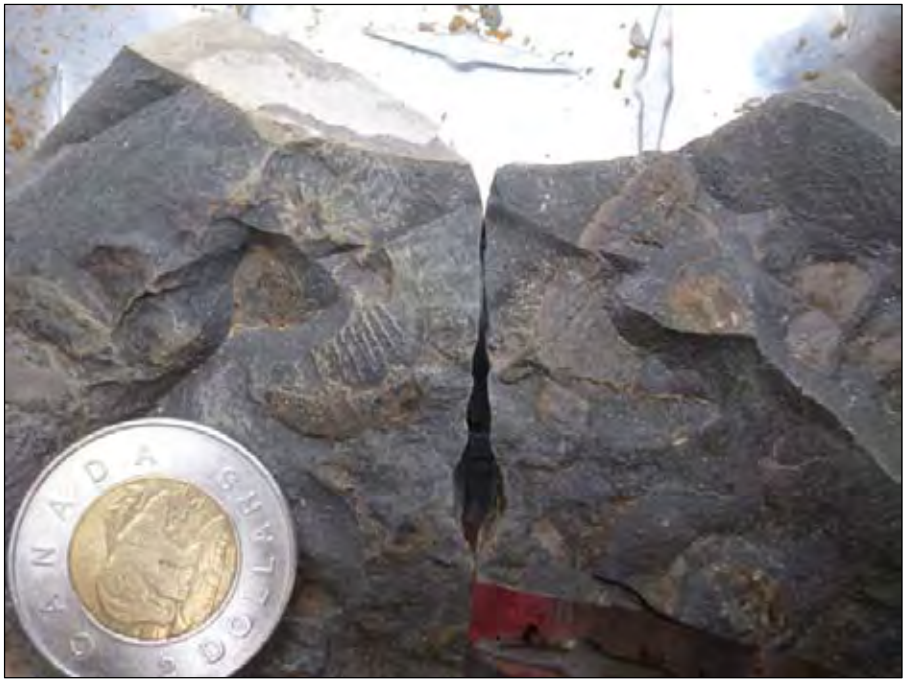


Photograph 156: Trace fossils (Zoophycos and Chondrites) from the Shaftesbury Fm at PS121D, along the Moberly River

Photograph 157: A neogastroplitid ammonite in a concretion from the Shaftesbury Fm in PS121D along the Moberly River

Photograph 158: Ammonite and fish skeletal debris within a concretion from the Upper Shaftesbury Fm near the edge of the LAA along the Moberly River at PS122B

Photograph 159: Location of abundant fish scales and skeletal elements in the Upper Shaftesbury Fm near the edge of the LAA along the Moberly River PS123C



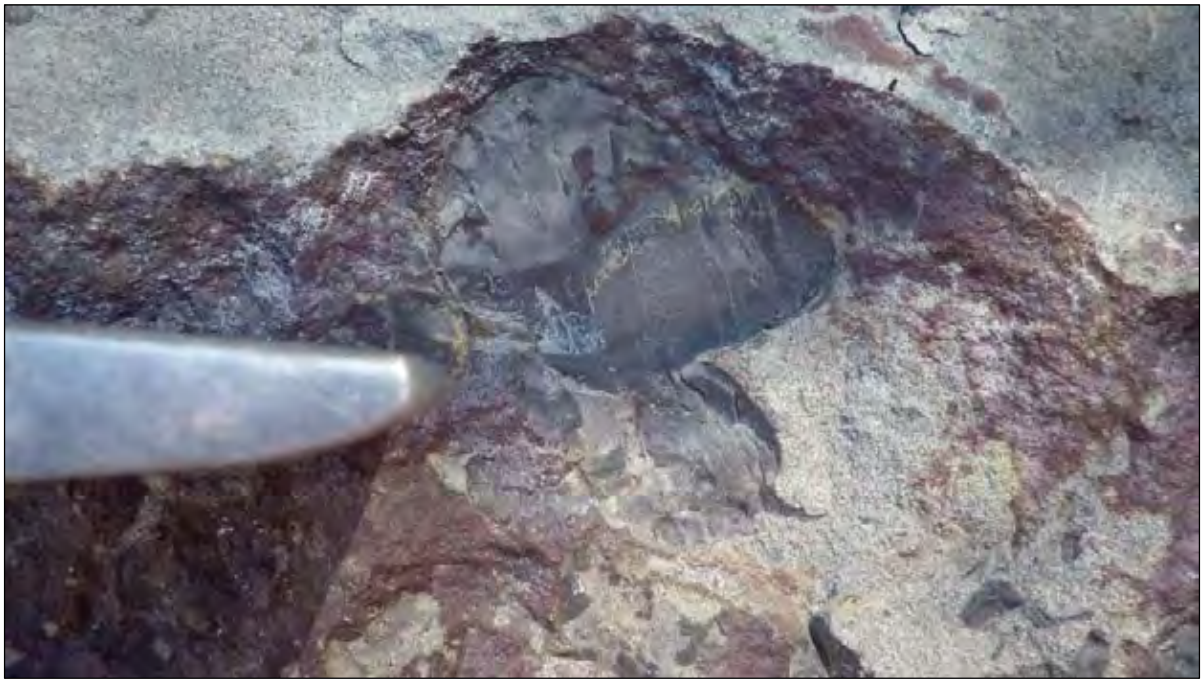
Photograph 160: Fossil fish scales and operculum (gill cover) in the shales from the Shaftesbury Fm in PS123C, located along the Moberly River near the edge of the LAA

Photograph 161: Thick, well bedded Quaternary sand and gravel deposits located just beyond the edge of the LAA in the Moberly River valley within PSX22Z

Photograph 162: Rabbit incisor tooth from Quaternary sediments in PSR01B7 along the upper bluffs in northeast Bear Flat, just uphill from the published rodent site at PSR01B8 (Hedba et al. 2008)

Photograph 163: Bedrock identified beneath a thin veneer of glacial sands on the upper south terrace of the Peace Canyon along the proposed transmission line in PST01B

Photograph 164: Zoophycos trace fossils in a dislodged sandstone block from the upper south terrace of the Peace Canyon along the proposed transmission line in PS0T1B



Photograph 165: Possible partial tooth embedded in ironstone from the Cruiser Fm in PST02E located along the proposed transmission line at the Maurice Creek crossing

Photograph 166: Diplocraterion trace fossil from the Cruiser Fm at PST02E along the proposed transmission line at the Maurice Creek crossing

Photograph 167: Planolites and Arencolites trace fossils on a rippled sandstone slab of the Cruiser Fm in PST03B along the proposed transmission line at the Maurice Creek crossing

Photograph 168: Exposure of the fossiliferous Cruiser Fm along Maurice Creek in PST03B

Photograph 169: Skolithos trace fossils in a sandstone cobble from the Cruiser Fm in PST05G along the proposed transmission line at the Moberly River crossing

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APPENDIX N

Photographs

Appendix N-1 – Palaeontology Photographs

Appendix N-2 – Archaeology Photographs

Appendix N-3 – Historical Photographs

Photograph 1: Excavated subsurface test

Photograph 2: Screening sediments from a subsurface test

Photograph 3: Using the Cartopac application on the Trimble Nomad to record field observations

Photograph 4: Archaeological survey areas were often accessed by boat

Photograph 5: Systematic surface inspection of a cultivated field

Photograph 6: Adaptive testing at HbRi-43

Photograph 7: In progress evaluative unit placed over positive shovel test 25097 at HaRk-46

Photograph 8: HbRh-36 - Backhoe test

Photograph 9: HaRk-46 - Deep shovel test

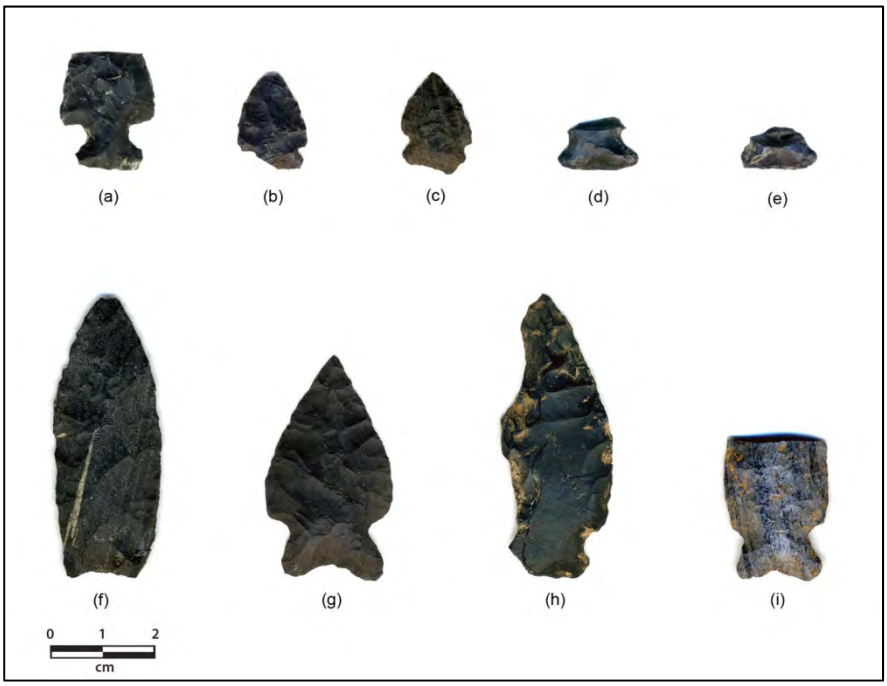
Photograph 10: HbRh-36 - Auger test

Photograph 11: Backhoe in operation and archaeological crews screening sediments from Trench 2 at HbRh-36

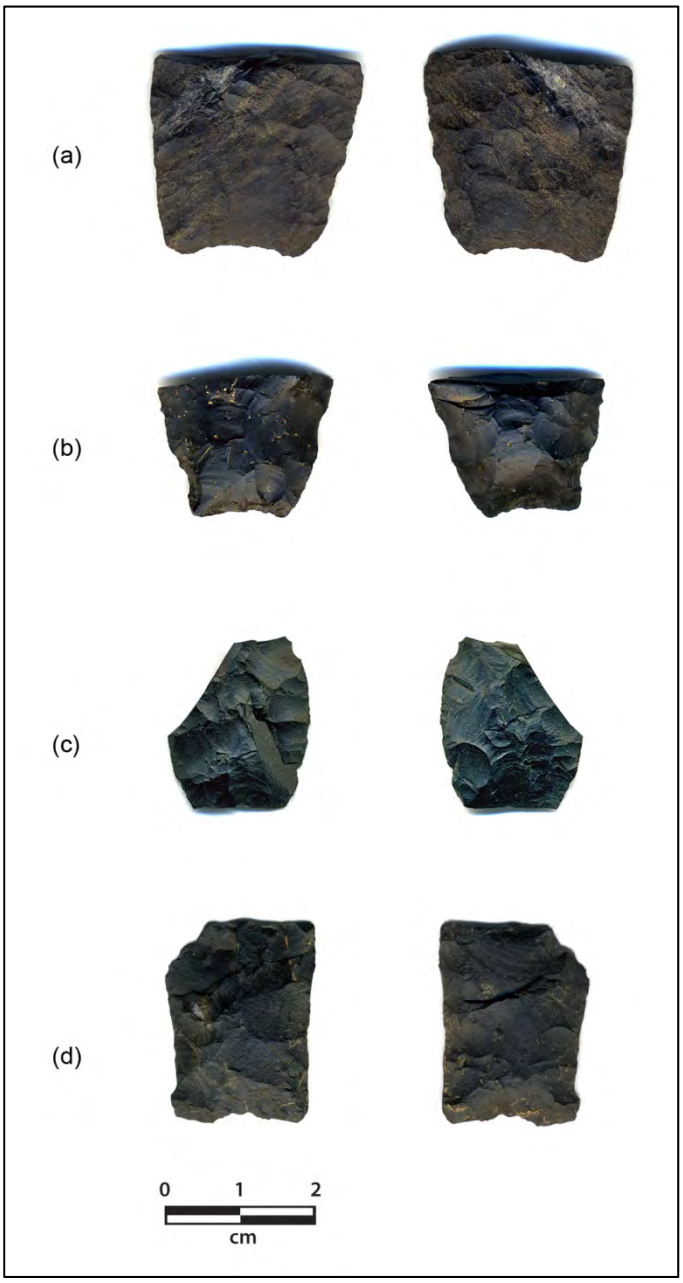
Photograph 12: HaRk-16 - Backhoe test

Photograph 13: Small landform survey in June

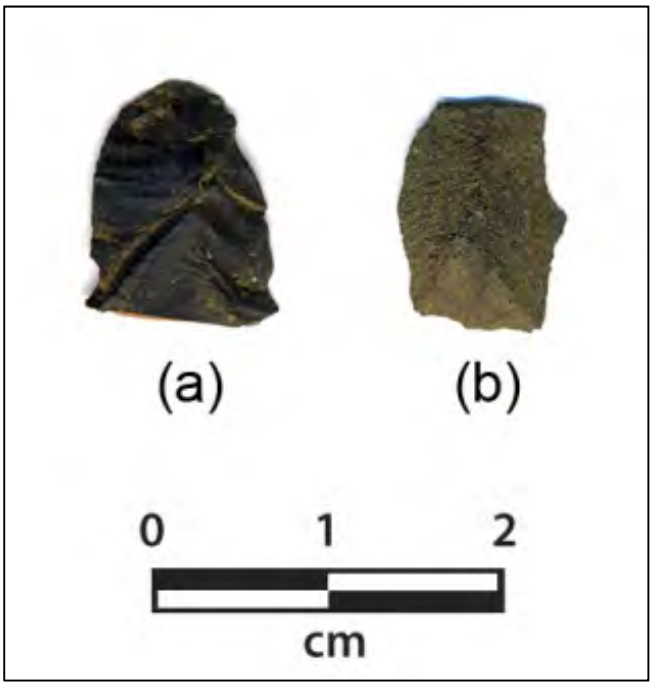
Photograph 14: Location of artifacts being recorded from a shovel test at HbRi-36



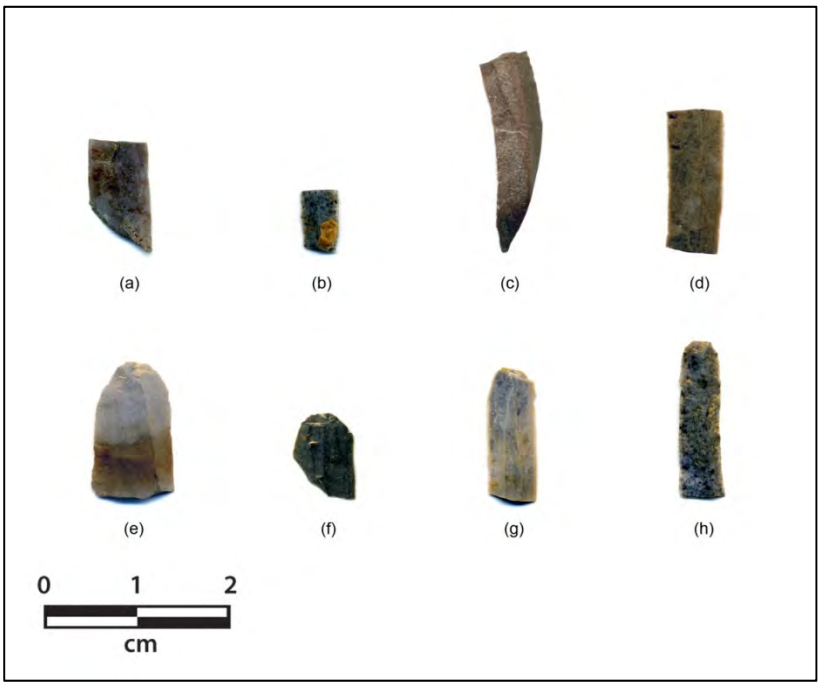
Photograph 15: Selected projectile points recovered in 2011 and 2012 (a: HbRh-145; b: HbRh-128; c: HaRj-23; d: HaRf-35; e: HbRf-115; f: GlRj-2; g: HbRf-94; h: HbRf-102; i: HbRh-36)



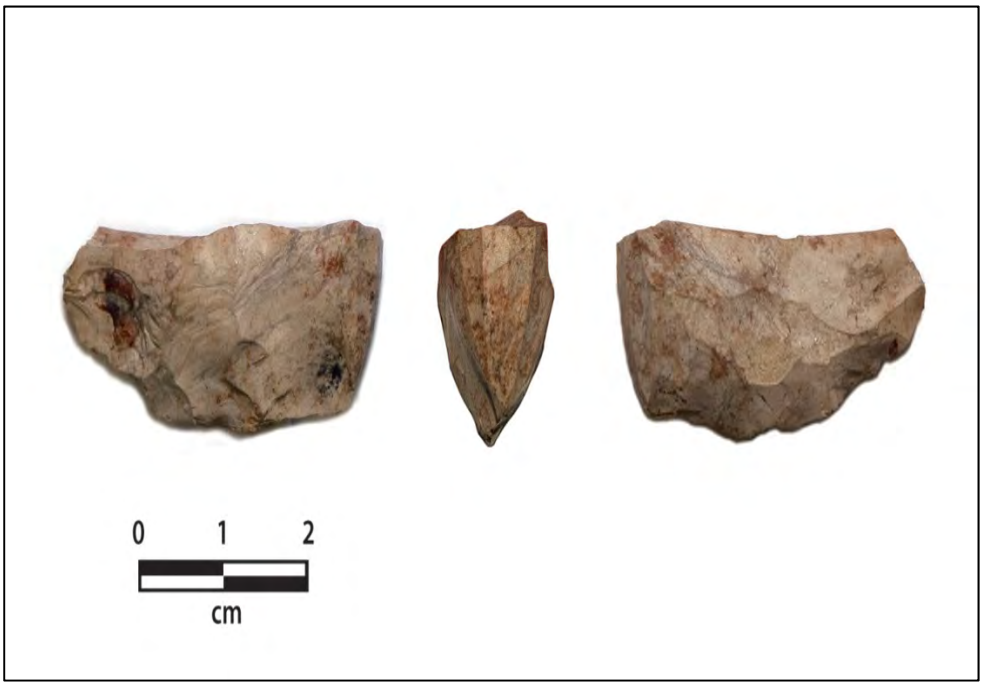
Photograph 16: Projectile point bases recovered in 2011 and 2012 (a: HbRh-136; b: HbRh-122; c: HbRi-58; d: HbRh-16)



Photograph 17: Microblade fragments recovered (a: HbRf-93; b: HbRh-122)



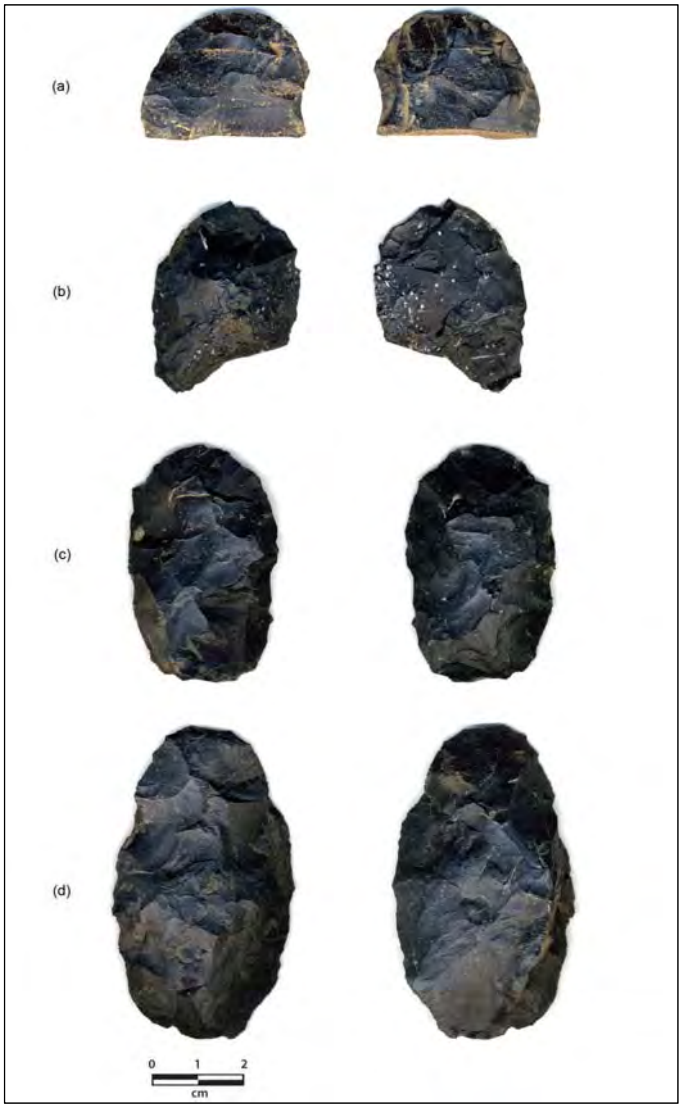
Photograph 18: Microblade fragments recovered in 2012 (a-b, e-h: HaRj-32; c-d: HaRf-32)



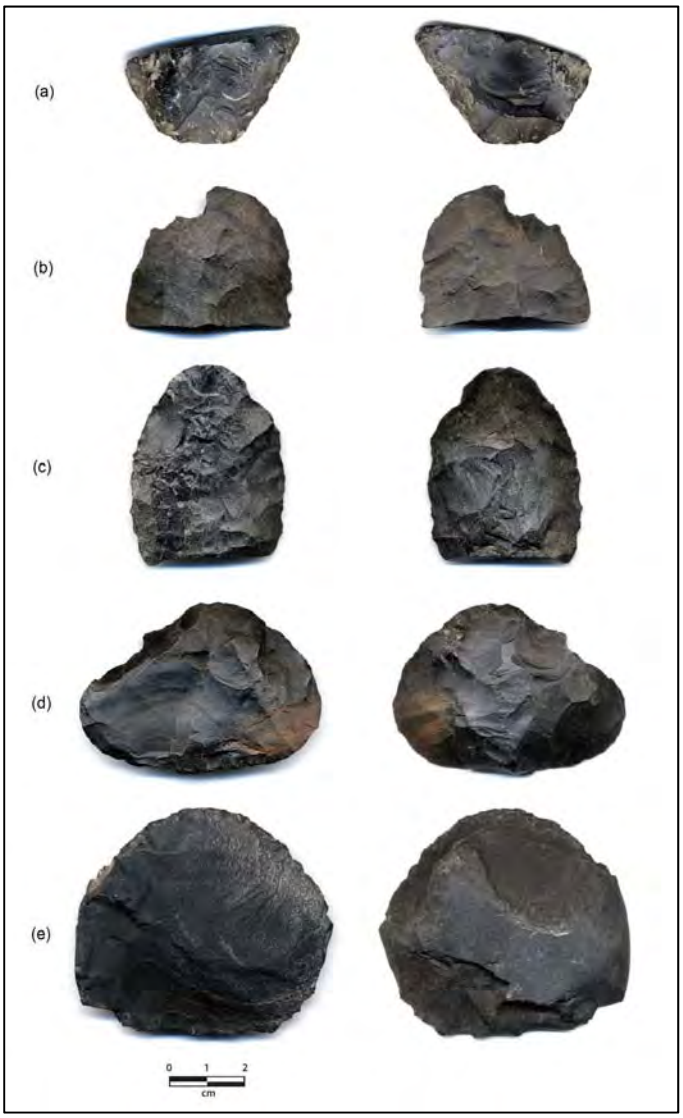
Photograph 19: Microblade core recovered from HaRj-32

Photograph 20: Macroblade fragment recovered from HaRj-27

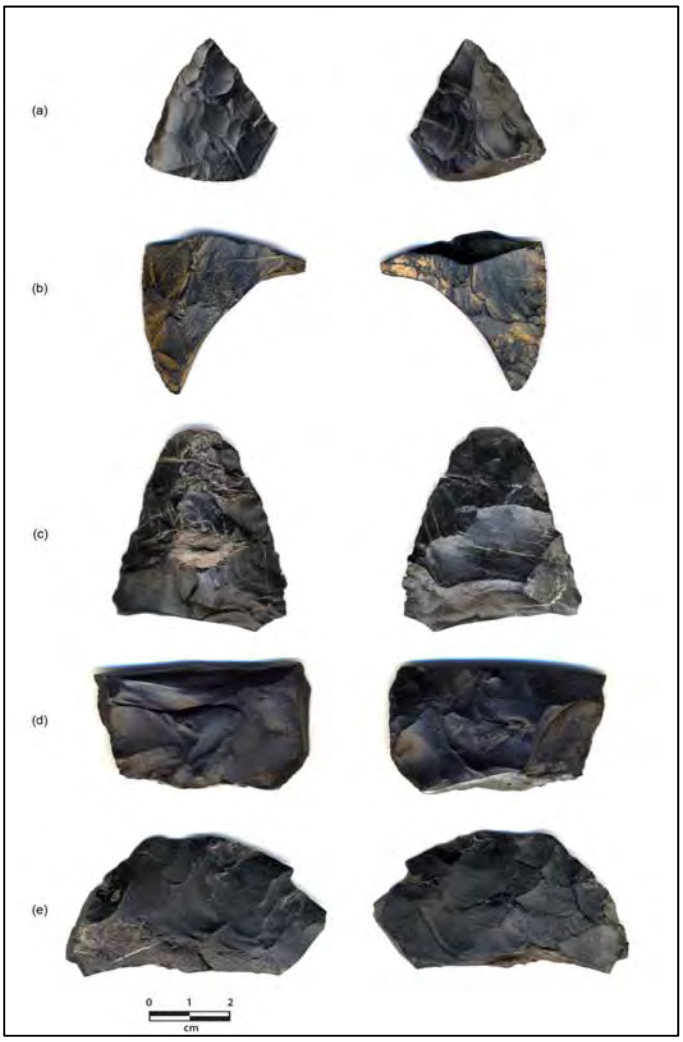
Photograph 21: Macroblades recovered from HbRi-43 (c and d were sourced to Mt. Edziza; all others from Anahim)



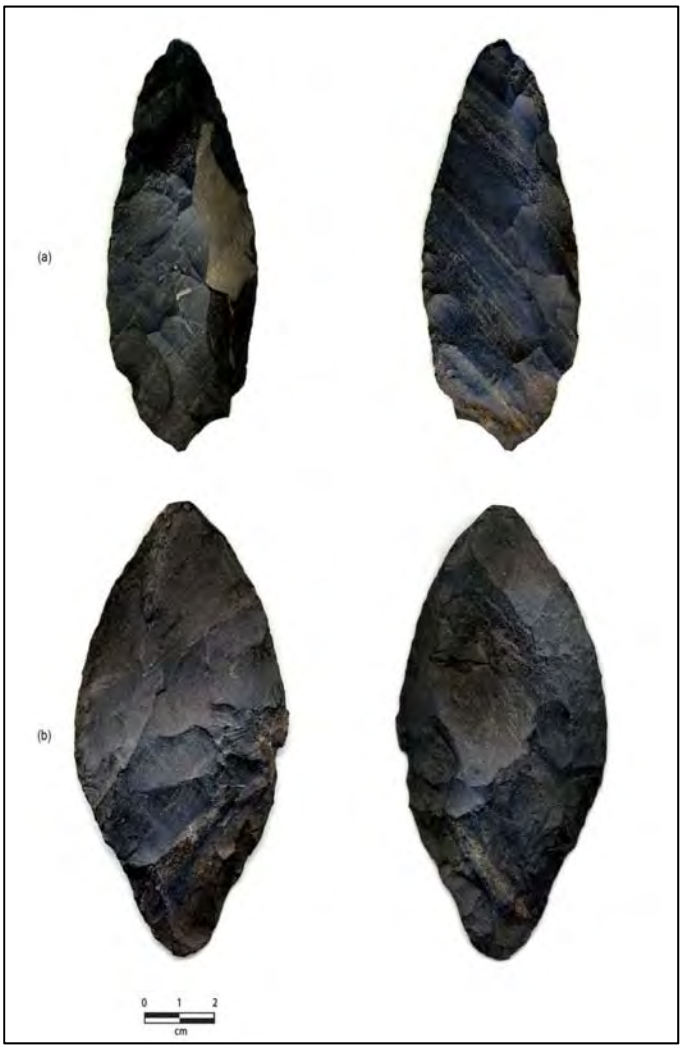
Photograph 22: Bifaces (a: HbRi-61; b: HbRf-61; c: HbRh-36; d: HbRg-49)



Photograph 23: Bifaces (a: HaRk-49; b: HbRi-41; c: HaRk-49; d: HbRg-49; e: HaRg-40)



Photograph 24: Large bifaces (a: HbRi-41; b: HbRf-102; c: HbRg-6; d: HbRg-5; e: HbRf-115)

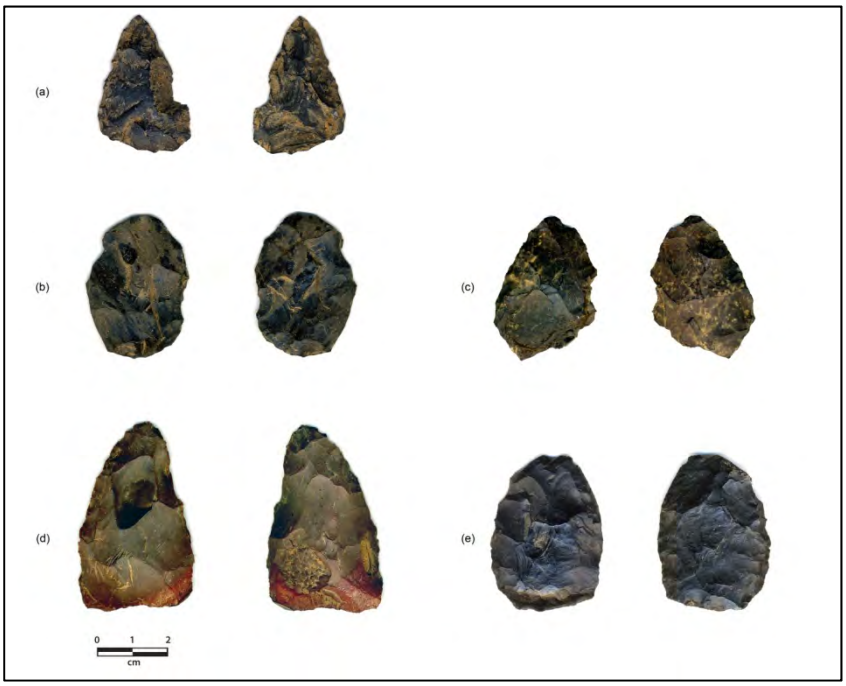


Photograph 25: Large complete bifaces (a: HaRk-52; HaRk-12)

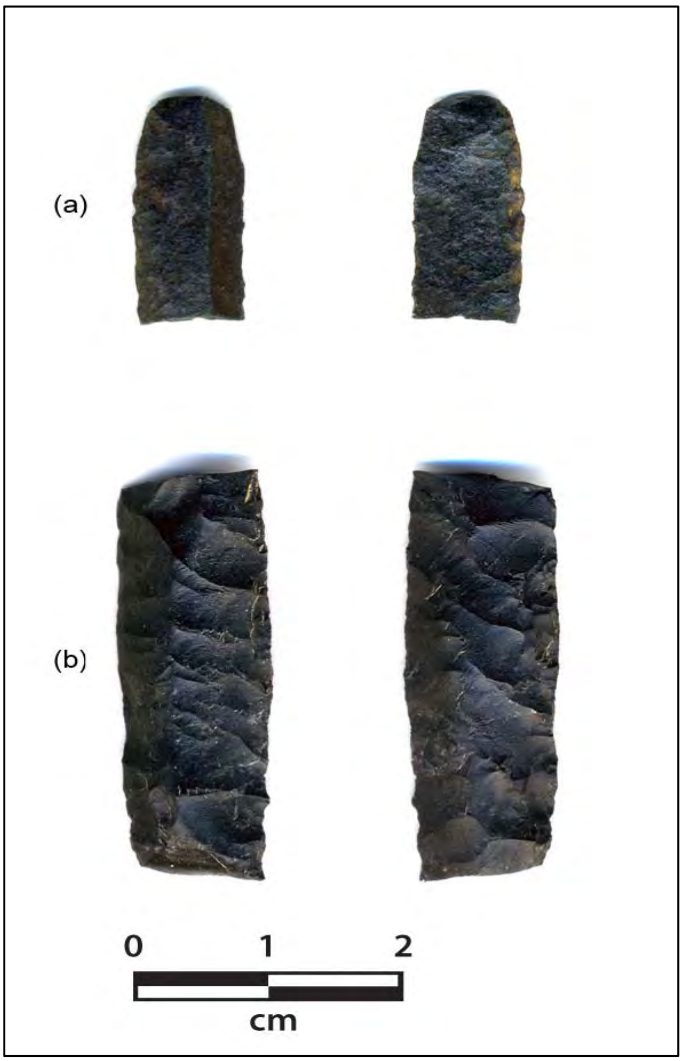
Photograph 26: Large complete biface recovered from HbRh-54

Photograph 27: Large complete biface recovered from HbRh-130

Photograph 28: A refitted lanceolate biface fragment from HbRg-5



Photograph 29: Bifacial preforms (a: HbRh-36; b: HbRh-122; c: GlRg-2; d: HaRk-38; e: HbRh-148)



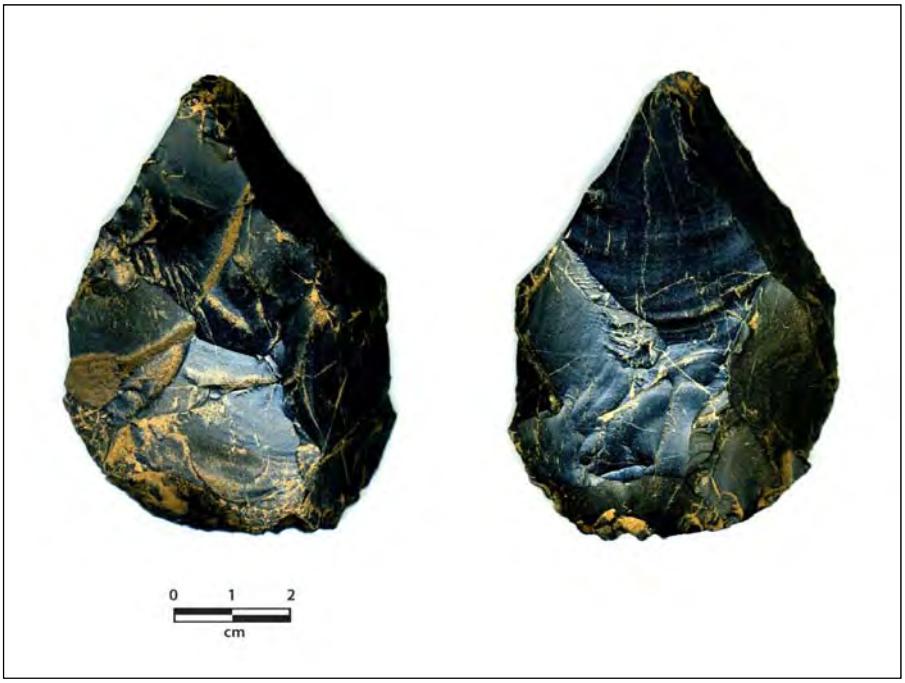
Photograph 30: Bifaces (a: HbRh-144; b: HbRh-57)

Photograph 31: Unidirectional core form HbRg-49

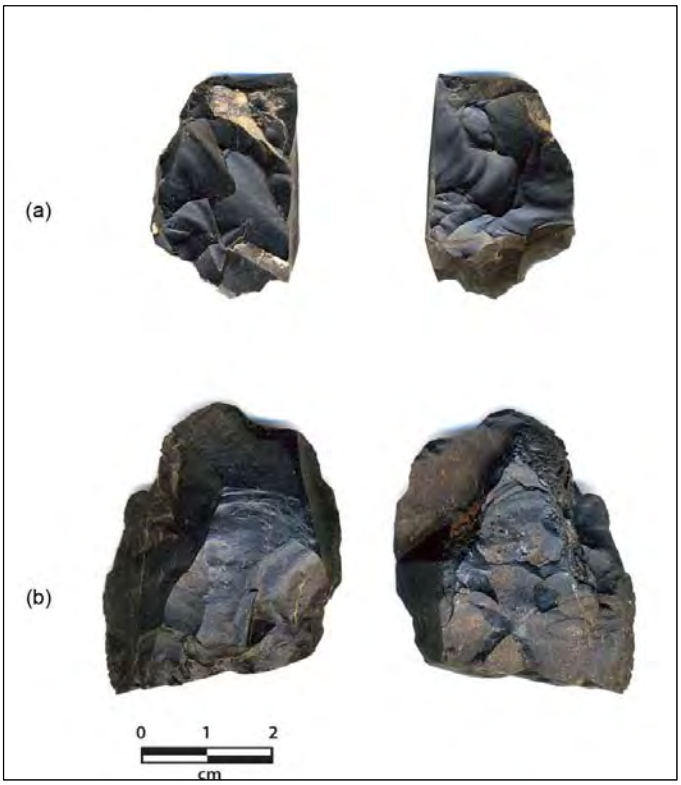
Photograph 32: Unidirectional core from HaRj-23

Photograph 33: Multidirectional core from HbRg-53

Photograph 34: Pièce esquillée from HbRi-61



Photograph 35: Bifacial core from HbRh-125

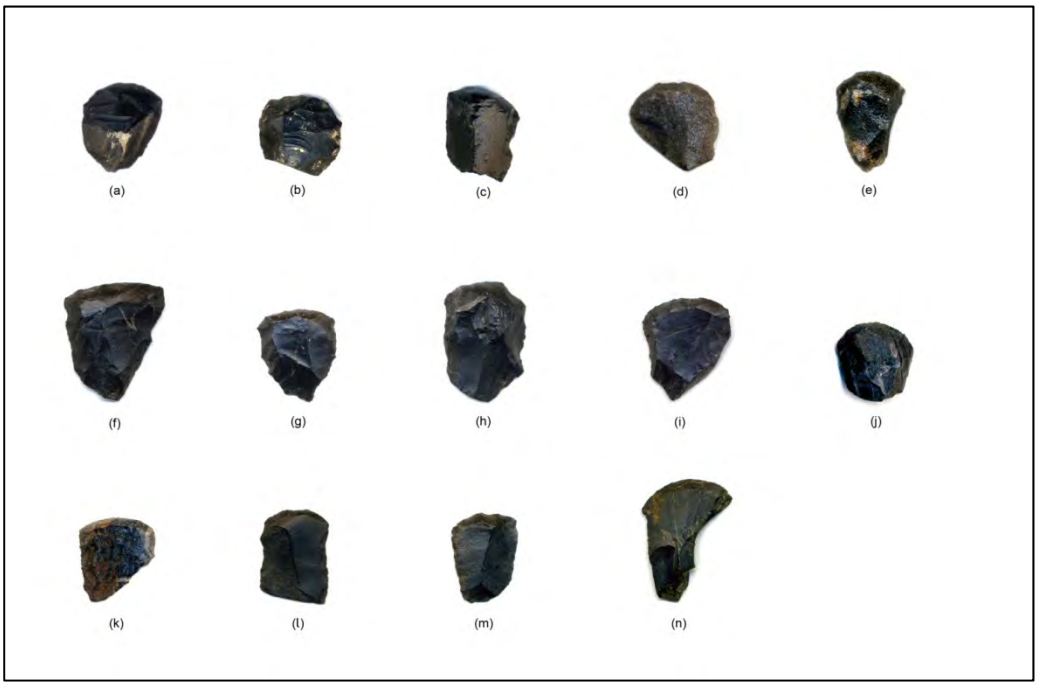


Photograph 36: Exhausted cores from HbRg-6

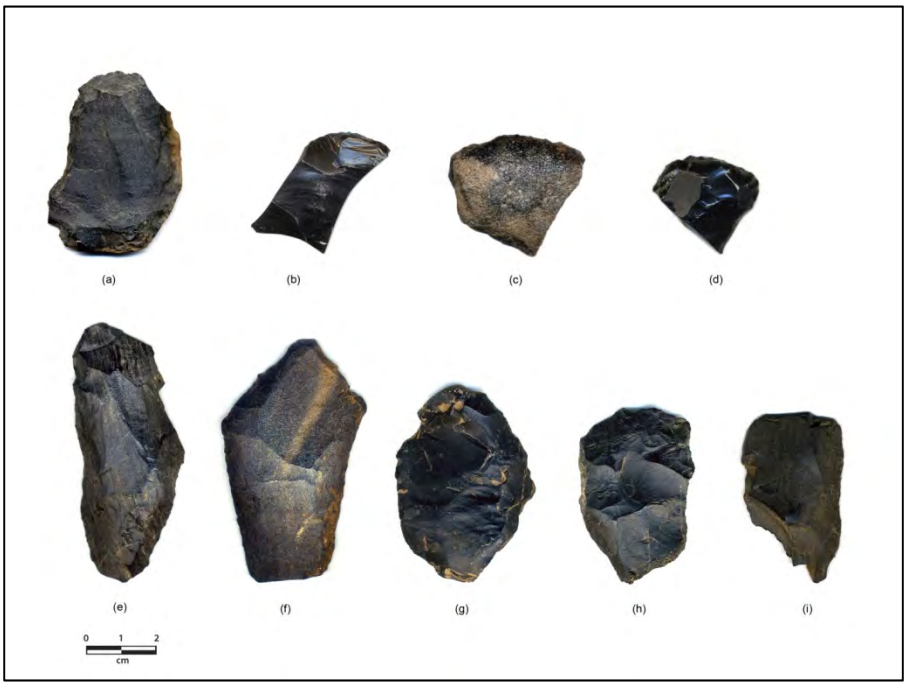
Photograph 37: Abrader from HbRh-122

Photograph 38: Quartzite spall tool from HbRg-5

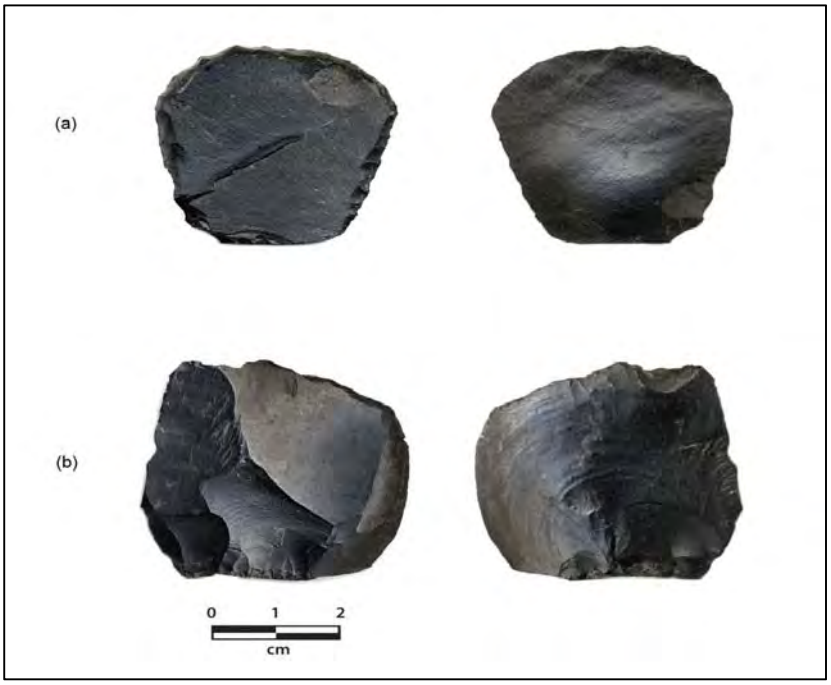
Photograph 39: Chi tho from HbRi-10



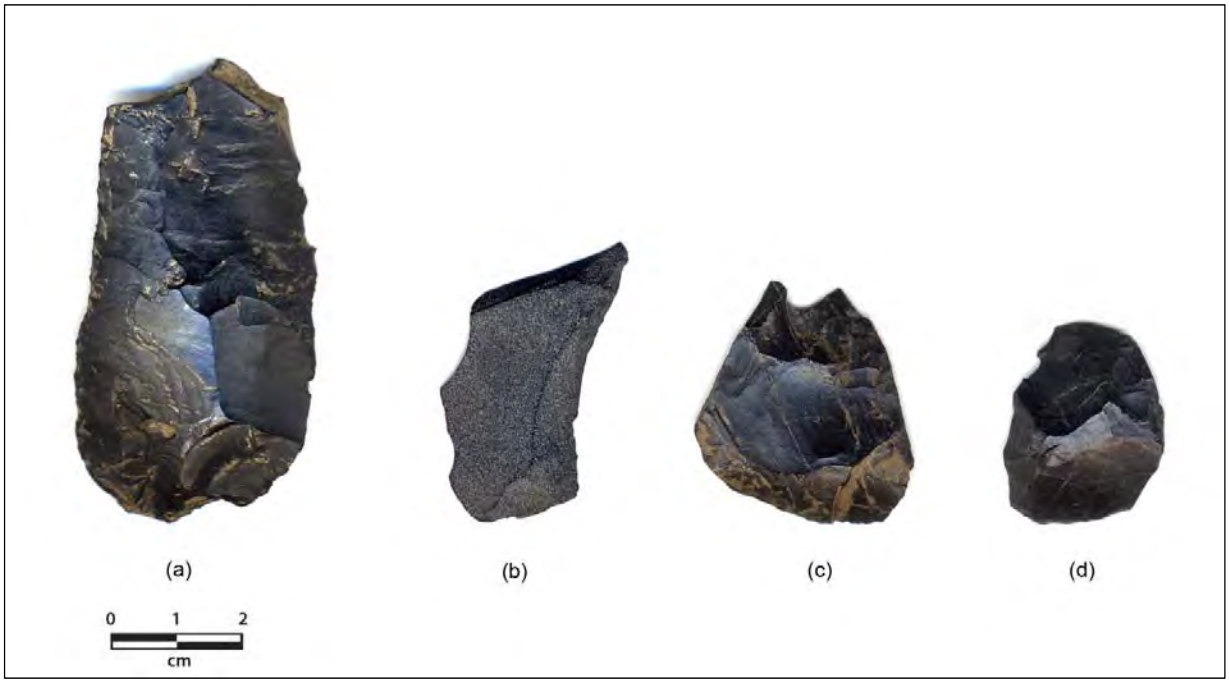
Photograph 40: Endscrapers recovered in 2011 and 2012 (a: HaRj-33; b: HbRi-6; c: HbRh-16; d: HbRh-8; e: HbRh-55; f: HaRj-34; g: HbRh-55; h: GlRj-2; i: HbRg-5; j: HbRg-53; k: GlRj-2; l: HbRh-12; m: HbRh-16; n: HbRi-61)



Photograph 41: Unifaces (a: HbRh-12; b: HaRf-32; c: HaRk-49; d: HbRg-11; e: HbRg-46; f: HaRf-27 ; g & h: HbRf-102; i: HbRh-122)



Photograph 42: Tabular unifaces (a: HbRi-41; b: HaRk-15)



Photograph 43: Unifaces from HbRg-6

Photograph 44: Example of the range of cherts present at transmission line sites (this material is from HaRj-32)

Photograph 45: Chalcedony flake recovered from HbRg-6

Photograph 46: Faunal remains recovered from HaRk-23

Photograph 47: View southeast from terrace overlooking Watson Slough

Photograph 48: View to Halfway - Peace confluence

Photograph 49: View north to east shore of Boucher Lake

Photograph 50: View northwest to wetlands at Watson Slough

Photograph 51: Wetlands

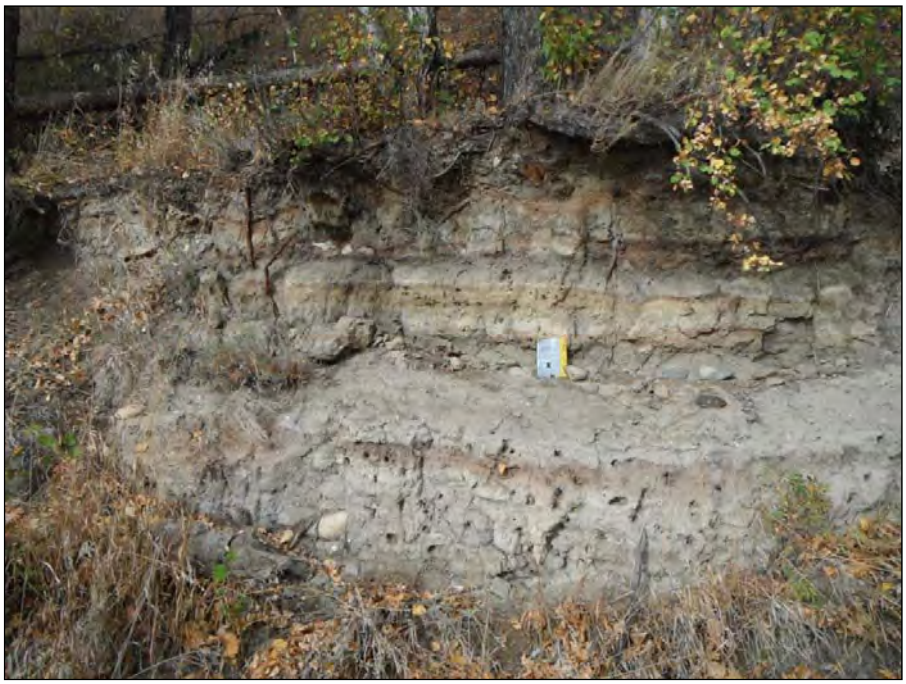
Photograph 52: View south to HaRf-26

Photograph 53: View northwest to the setting of HaRf-27

Photograph 54: HaRf-34 – View southeast

Photograph 55: HaRf-34 - Bone fragments

Photograph 56: View southwest to the setting of HaRj-19



Photograph 57: Soil profile on the eroded remnant terrace down-slope from the main deposit at HaRk-1

Photograph 58: Bench at HaRk-1, below the main site deposit

Photograph 59: View southwest from HaRk-35

Photograph 60: HbRh-2 landscape

Photograph 61: Plowed Field –view west towards HbRh-29

Photograph 62: HbRj-6 – View northwest to probable location of recorded site

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Photograph 1: HaRj-23 – View southeast to the Moody Cabin (2012).

Photograph 2: HaRj-23 –View west to the Moody Cabin (2012).

Photograph 3: HaRj-23 – Three artifacts identified near terrace edge of Structure 2 (2012).

Photograph 4: HaRj-23 – Ceramic hollowware (2012).

Photograph 5: HaRj-23 – Tobacco can lid with embossed "COPENHAGEN/SNUFF" and CW logo (2012).

Photograph 6: HaRk-34 – View southwest to the Farrell Cabin (2012).

Photograph 7: HaRk-34 –Farrell Cabin – View northeast to the gable ends, south corner of the Farrell Cabin (2012).

Photograph 8: AMB-T4 - View west to partially intact cabin (2011).

Photograph 9: AMB-T4 - View north to partially intact cabin (2011).

Photograph 10: AMB-T4 – View southeast to cabin, illustrating construction detail (2012).

Photograph 11: AMB-12-2 – View north along old Highway road bed (2012).

Photograph 12: H-12-G10-A – View northwest to wagon road cut (2012).

Photograph 13: H-12-G10-A – View southeast to wagon road cut and upper terrace (2012).

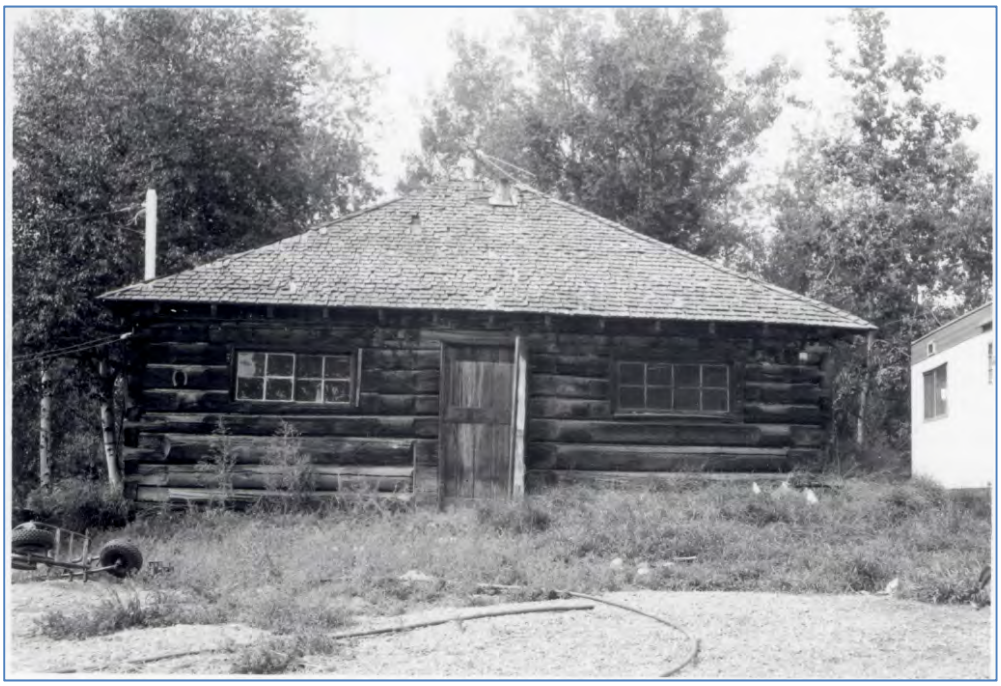
Photograph 14: AMB-T6 – View west to blazed aspen, CMT 10 (2012).

Photograph 15: AMB-T6 – View west to trail along terrace edge (2012).

Photograph 16: HbRg-28 – View northwest to the Flatt Barn, Peace Valley Ranch (1977).

Photograph 17: HbRg-28 – View north to the Flatt Bunkhouse, Peace Valley Ranch (1977).

Photograph 18: HbRg-28 – View south to "Feature 12", probable location of former main dwelling (2011).



Photograph 19: HbRh-61 – View west to the Watson Cabin (1977).

Photograph 20: HbRh-61 – View east to the Watson Bunkhouse (1977).

Photograph 21: HbRh-61 – View east to probable location of Watson's Cabin (2011).

Photograph 22: HbRh-61 - View northeast to probable location of the Watson Bunkhouse (2011).

Photograph 23: HbRh-61 – Manufacturer's plate on POMONA Air Cleaner (2012).

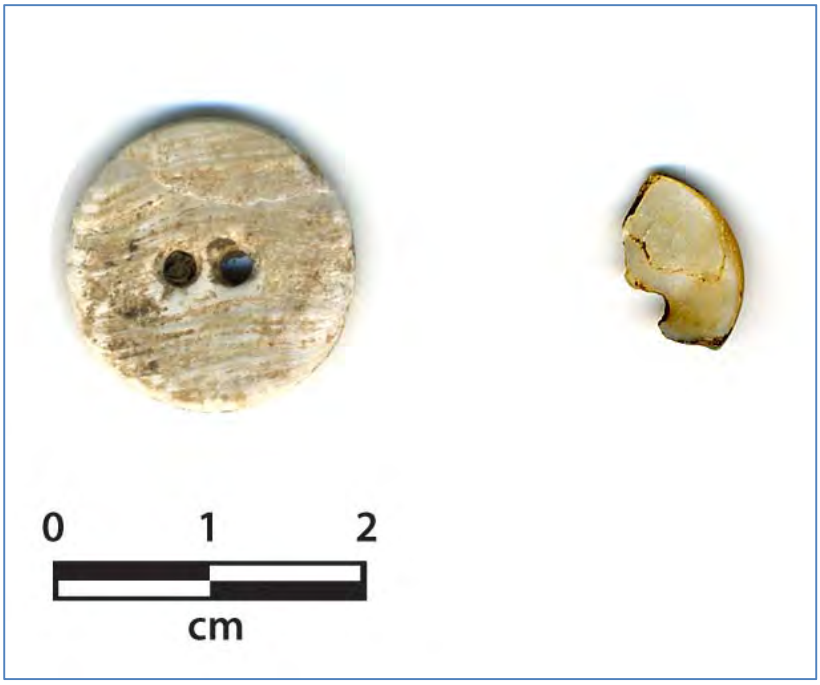
Photograph 24: AMB-12-3 – Base of ceramic piece embossed " _NGLAND".

Photograph 25: AMB-12-4 – Metal file with reworked tip.

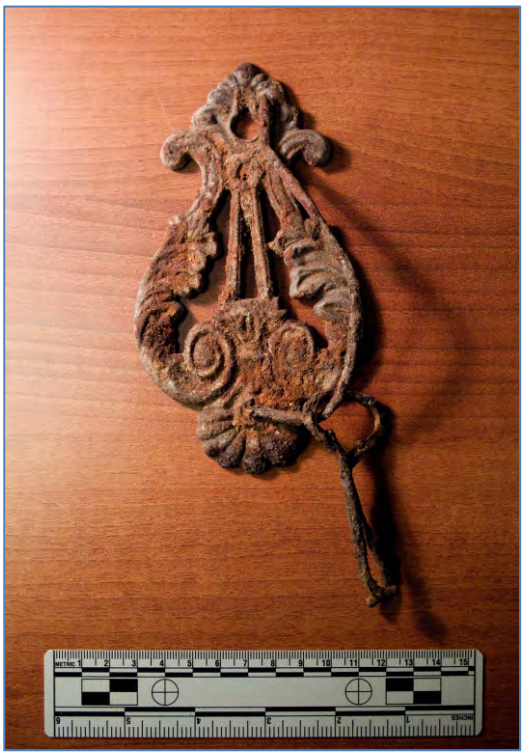
Photograph 26: HbRi-10 – English refined white earthenware teacup with willow pattern.

Photograph 27: AMB-12-1 – Large piece of cast iron.

Photograph 28: AMB-12-1 – Shell button, two-hole, with fish-eye shaped well.



Photograph 29: AMB-12-1 – Shell button (left) and HbRi-10 – shell button (right).



Photograph 30: AMB-12-1 – Escutcheon, with decorative cast iron scrolling pattern and keyhole; the wire handle is partially attached with a bent wire loop.

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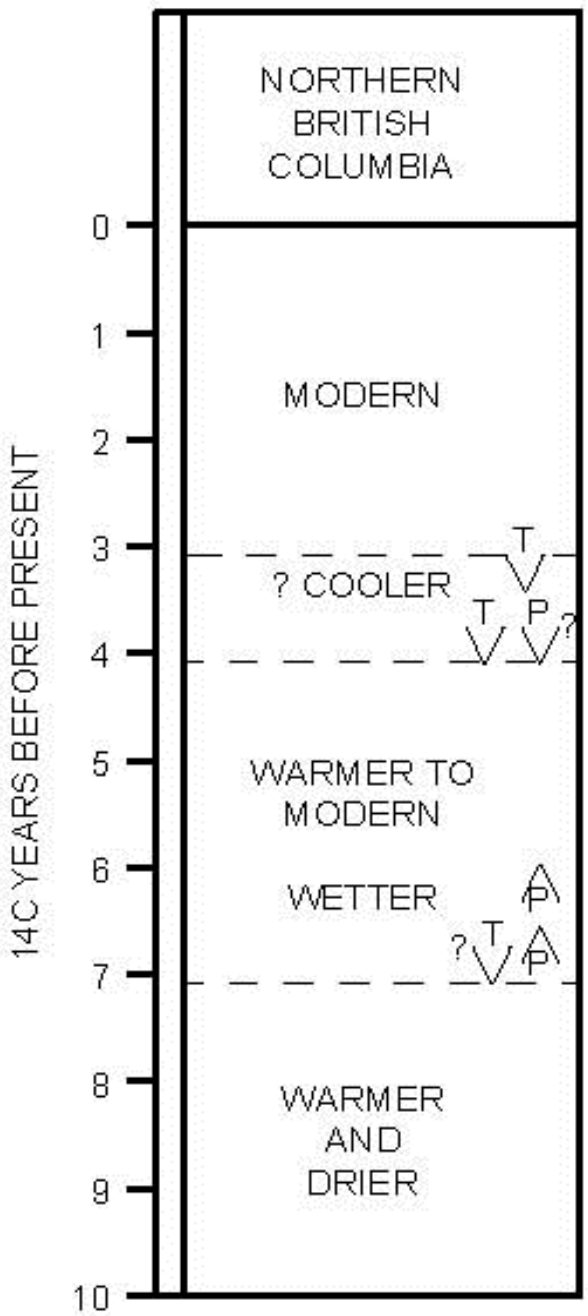

SOURCE
MODIFIED FROM HEBDA 1995

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Figure 3.1 Summary of northern British Columbia holocene climate trends

PERIOD	PLAINS: Reeves 1986; Vickers 1986	PLAINS: Peck 2011	SOUTHWESTERN NWT: Clark 2001; Miller 1981 — Phase	SOUTHWESTERN NWT: Clark 2001; Miller 1981 — Complex	SOUTHERN YUKON: Hare 1995; Workman 1978	DATE B.P.
LATE	Late side-notched	One Gun Old Women's High wood Old Women's Avonlea Sonota Besant Bracken Outlook / Sandy Creek Pelican Lake McKean Oxbow Estevan Calderwood Maple Leaf Mummy Cave Country Hills Lusk Plains / Mountain Cody Alberta Agate Basin Basally thinned Folsom Clovis	River of the Mountains	Fort Liard	Bennett Lake Phase	0
				Nande Creek	Aishihik Phase	500
	Besant / Avonlea			Petitot River	Taye Lake Phase	1000
				Mackenzie		1500
	Sandy Creek / Pelican Lake			Albert Thomas Lakeshore		2000
			Grand River (Late Northwest Microblade Tradition)			2500
	Oxbow / Hanna Duncan McKean			Julian		3000
				Transitional		3500
				Pointed Mountain		4000
					Annie Lake Complex	4500
MIDDLE	Mummy Cave		Nakah (Northern Plano Tradition)	Klondike	Little Arm Phase	5000
						5500
						6000
						6500
						7000
						7500
EARLY	Foothill / Mountain			Codille		8000
				Kooteneelee		8500
	Scottsbluff / Alberta / Cody				Northern Cordilleran / Paleo-Arctic	9000
	Agate Basin / Hell Gap					9500
						10000
	Folsom Goshen Clovis					10500
						11000
						11500
				McLoed Mountain		12000

SOURCE:
ADAPTED FROM WORKMAN (1978), MILLAR (1981), REEVES (1983), VICKERS (1986), HARE (1995), CLARK (2001), AND PECK (2011)

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Figure 3.2 Composite cultural sequences

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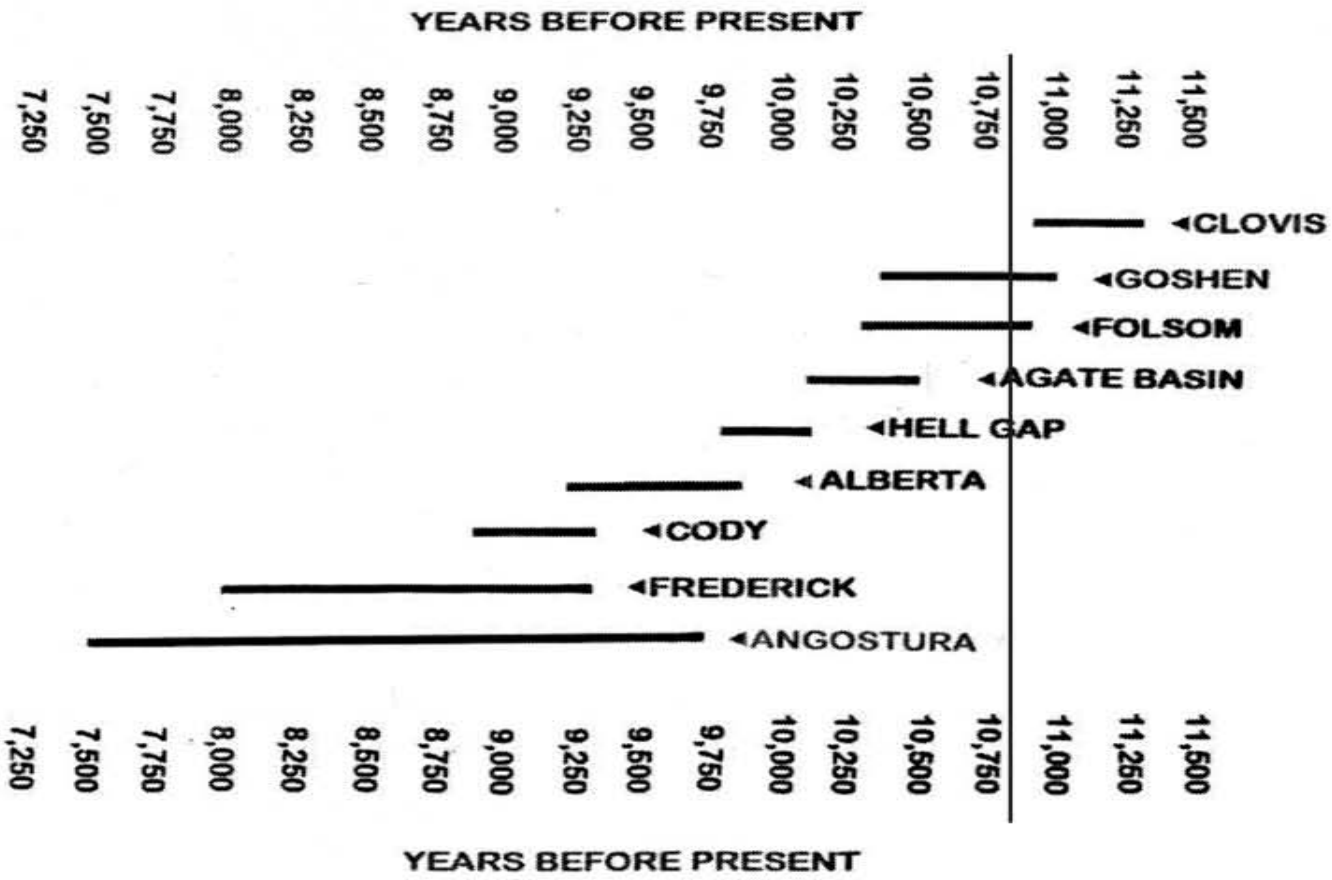

SOURCE
ADAPTED FROM PETTIPAS 2011

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Figure 3.3 Western Palaeoindian complexes – traditions sequence

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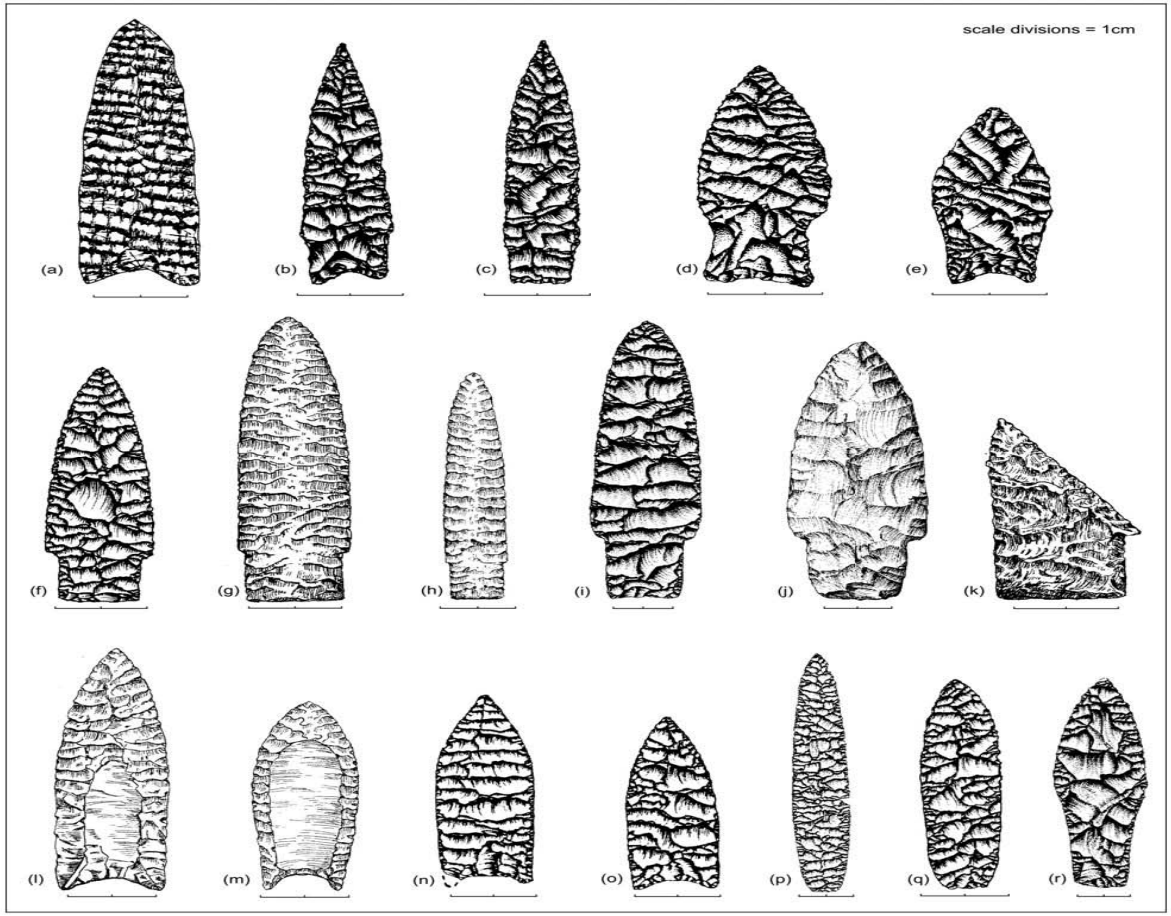

KEY
(a) FREDERICK; (b-e) FOOTHILLS/MOUNTAIN COMPLEX; (f-g) SCOTTSBLUFF; (h) EDEN; (i-j) ALBERTA; (k) CODY KNIFE; (l) CLOVIS; (m) FOLSOM; (n-o) GOSHEN; (p-q) AGATE BASIN; (r) HELL GAP

SOURCE
(a) FROM VICKERS 1986; (b-f, i, n-r) FROM FRISON 1991; (g-h, k-m) FROM WORMINGTON 1964; AND (j) FROM FLADMARK 1980

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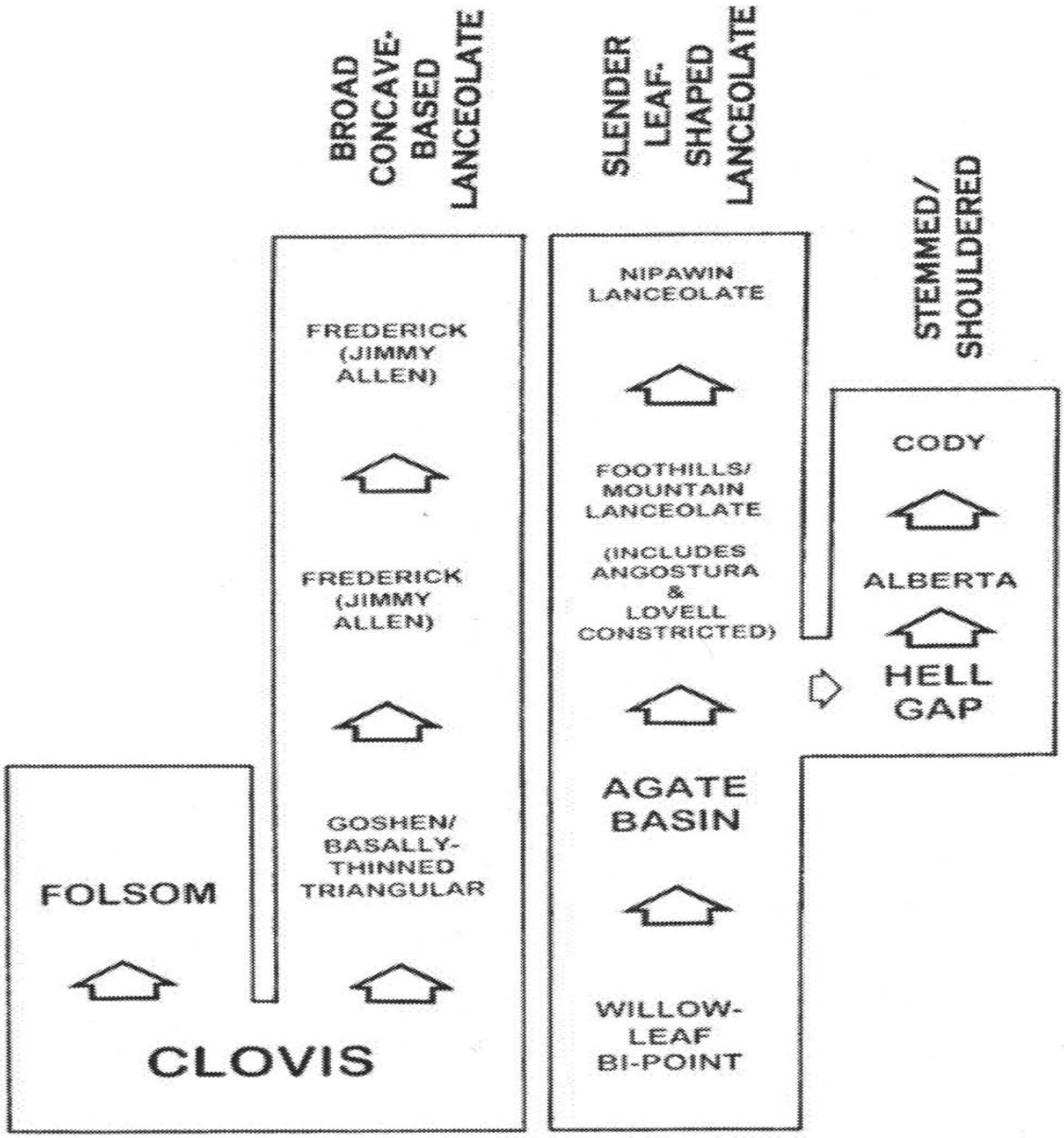
Figure 3.4 Palaeoindian projectile points



SOURCE
ADAPTED FROM PETTIPAS 2011

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Figure 3.5 Provisional projectile point co-tradition sequences

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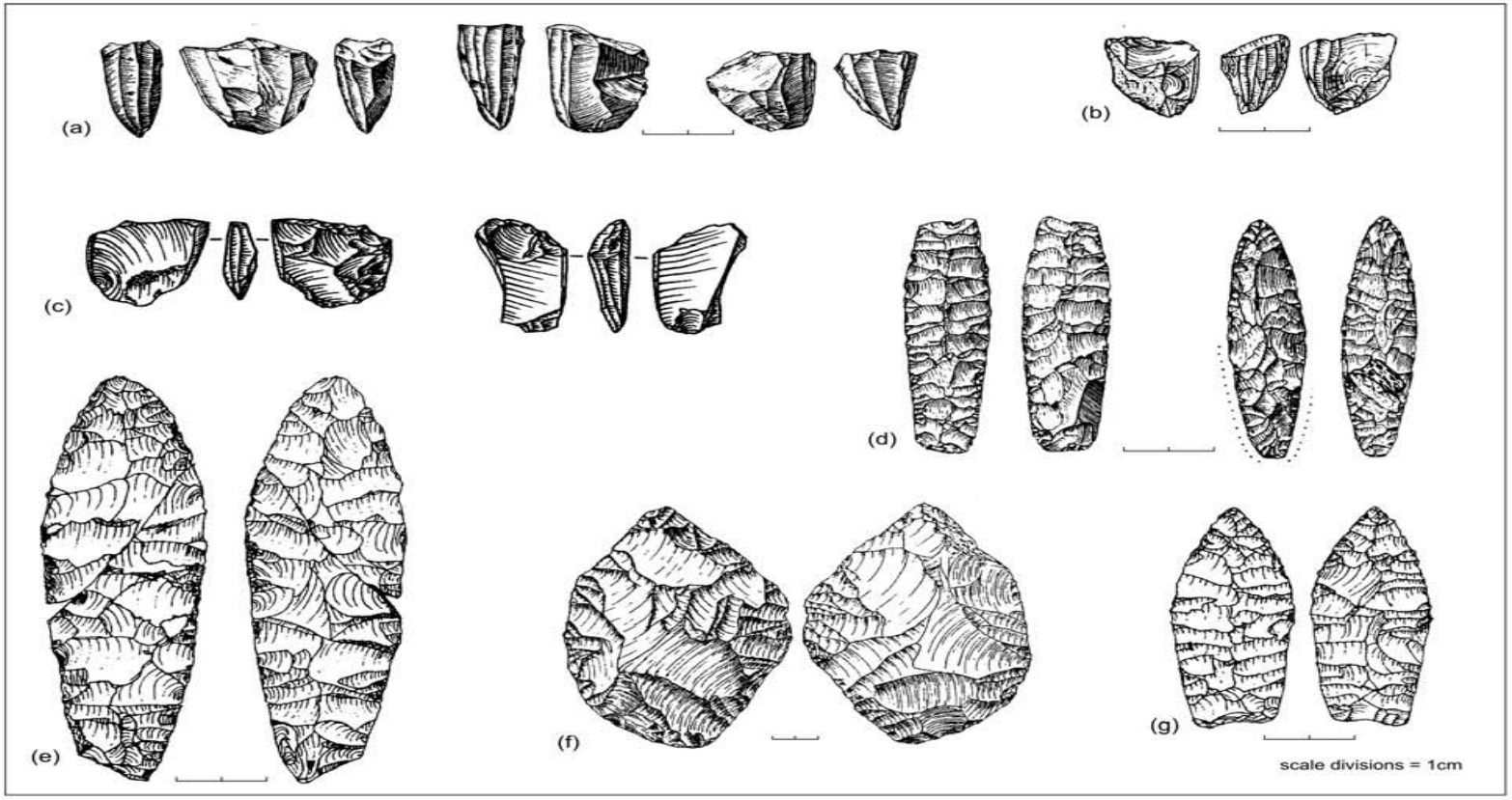

KEY
(a and b) MICROBLADE CORES; (c) MULTIFACTED CORE BURINS; (d) LANCEOLATE PROJECTILE POINTS; (e) PROJECTILE POINT; (f) LARGE BIFACE; (g) PROJECTILE POINT

SOURCE
(a) FROM GERLACH AND HALL 1996; (b) FROM ACKERMAN 1996; (c) FROM CLARKE AND GOTTHARDT 1999; (d) FROM REANIER 1996; (e) FROM WEST; AND (f and g) FROM KUNZ AND REANIER 1996

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Figure 3.6 Paleo-arctic and northern cordilleran artifacts

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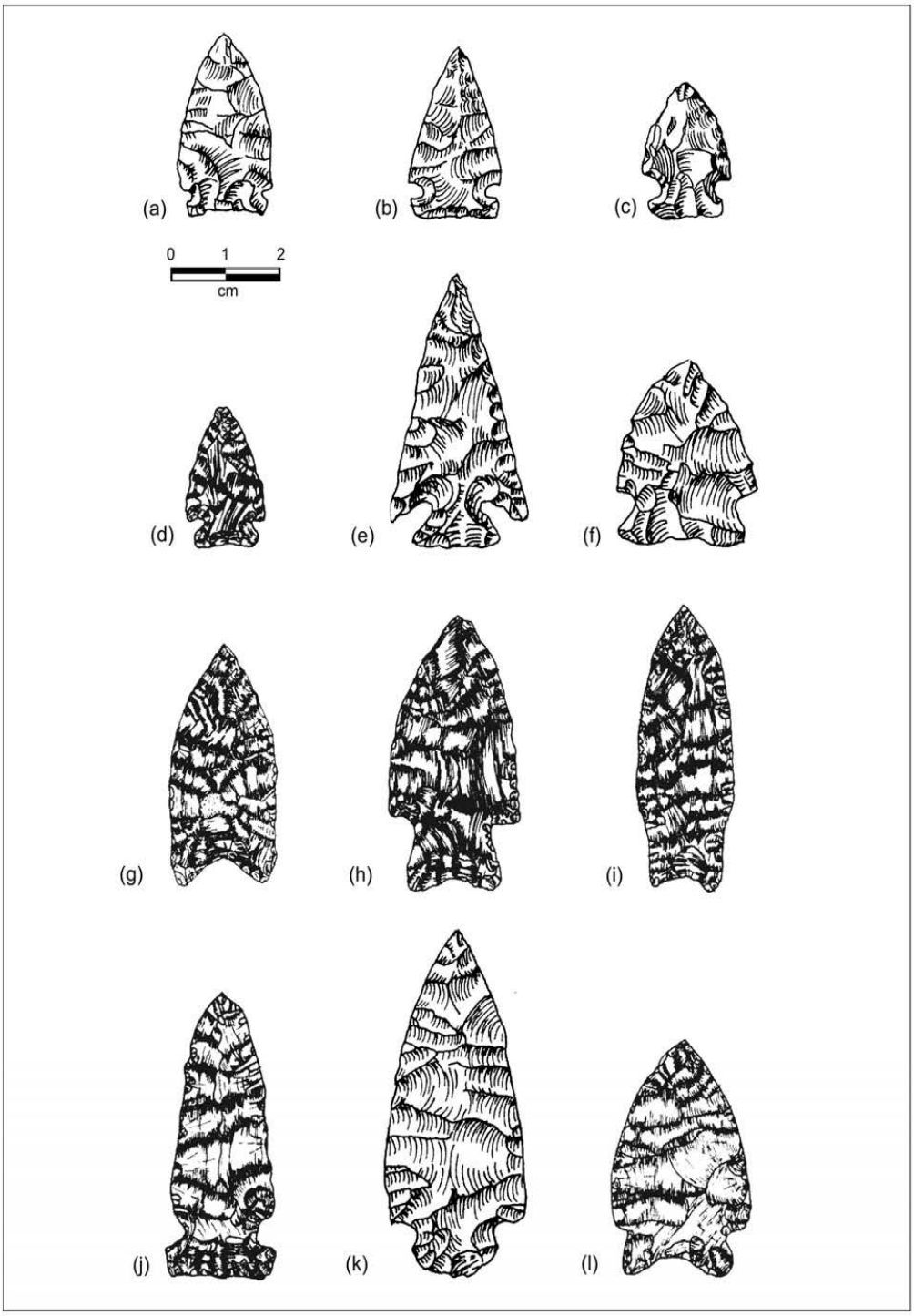

KEY
(a) AVONLEA; (b) PLAINS SIDE-NOTCHED; (c) PRAIRIE SIDE-NOTCHED; (d) HEAD-SMASHED-INCORNER-NOTCHED; (e) PELICAN LAKE; (f) BESANT; (g) MCKEAN; (h) HANNA; (i) DUNCAN; (j) BITTERROOT SIDE-NOTCHED; (k) BOSS HILI; (l), OXBOW

SOURCE
(a-c, e, f, k-l) FROM HELGASON 1987; (g-j) FROM VICKERS 1986

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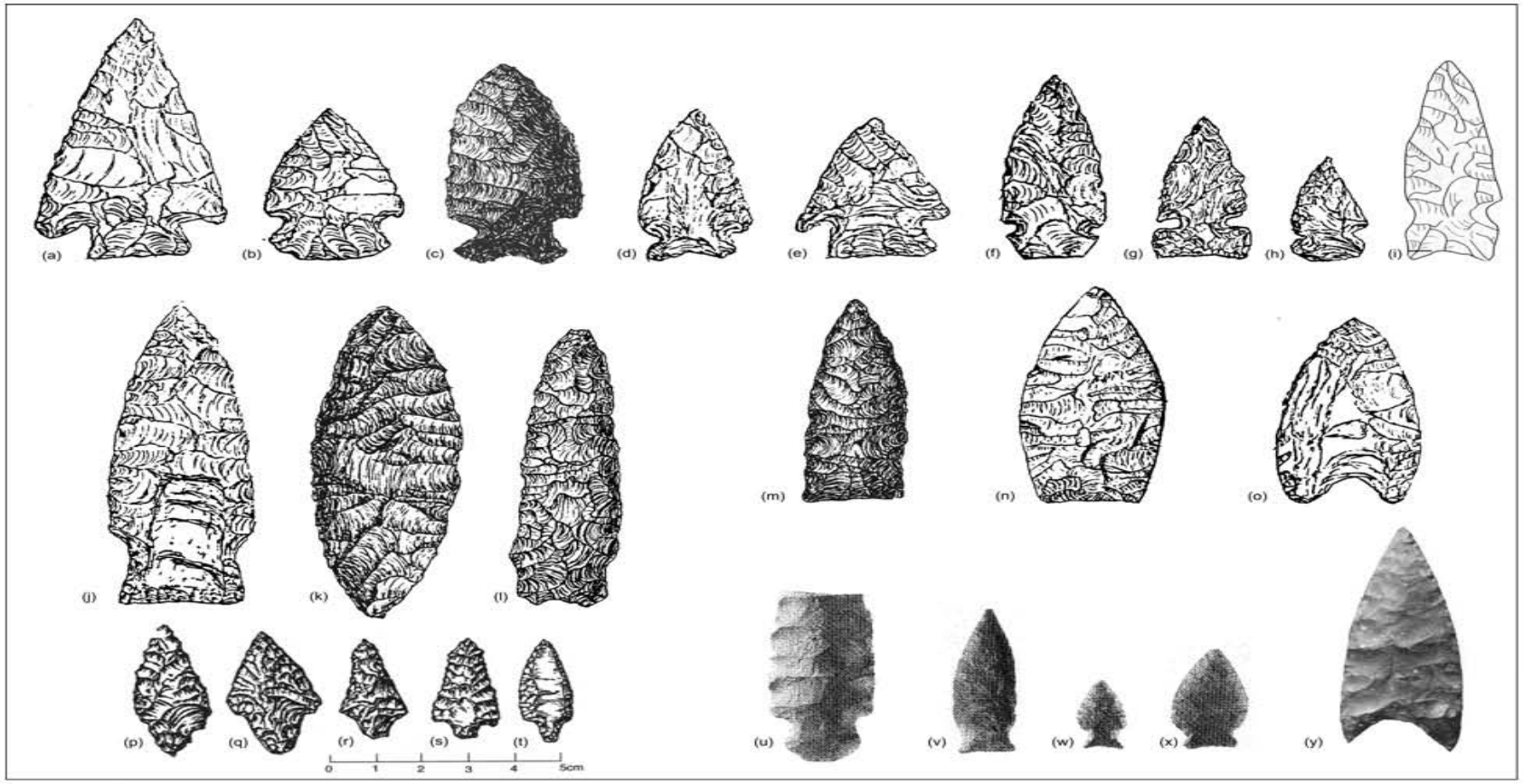
SITE C CLEAN ENERGY PROJECT

Figure 3.7 Middle to late plains projectile points



KEY
(a – h) NOTCHED PROJECITLE POINTS; (j-o) STEMMED-LANCEOLATE PROJECTILE POINTS; (p-t) KAVIK POINTS; (u) KAMUT POINT; (v-x) NOTHERN ARCHAIC POINTS; (y) ANNIE LAKE POINT

SOURCE
[(a – b, d – i, m – o) FROM SEWELL 1950-55; (I) FROM MATSON AND MAGNE 2007; (c, j – l) FROM FLADMARK 1985; (p – t) FROM WILSON 1978; (u – x) FROM CLARK 1991; (y) FROM GREER 1993

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Figure 3.8 Interior plateau projectile points

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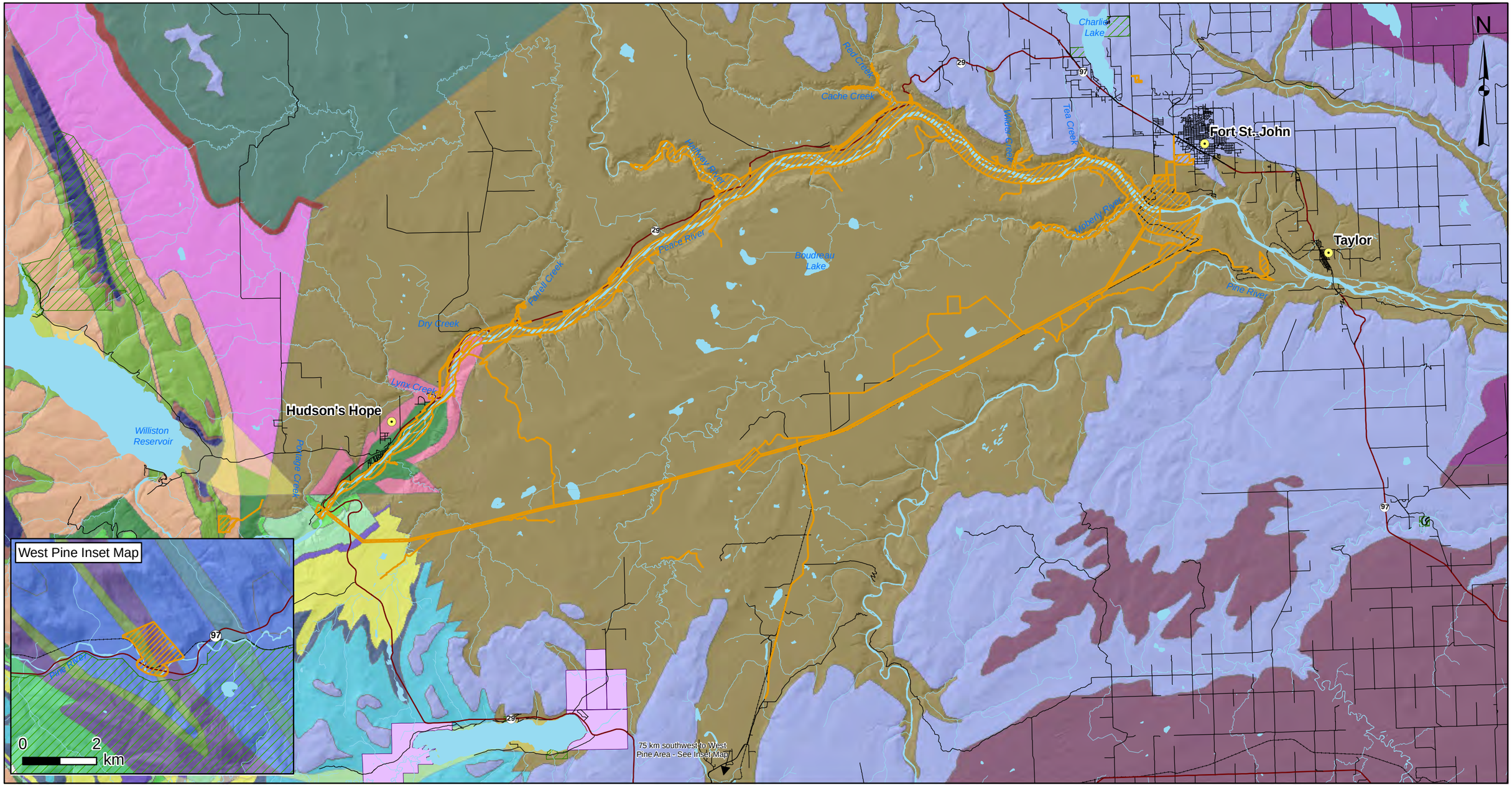
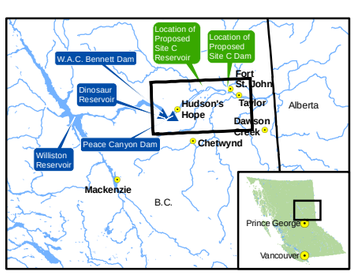
Figures 4.5 through 4.8 contain sensitive information that has been redacted from the public version of the Site C Clean Energy Project Environmental Impact Statement





Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
3. Bedrock geology obtained from the Ministry of Energy, Mines and Natural Gas and Responsible for Housing.

Legend

- Heritage Resources Local and Regional Assessment Area
- Protected Areas, Provincial Parks, Regional Parks and Ecological Reserves.
- Indian Reserve
- Existing Road
- Existing Highway
- Existing Railway
- City/District Municipality
- Quaternary Geology
- Fort St. John Group
- Fort St. John Group - Boulder Creek Formation
- Fort St. John Group - Cruiser Formation
- Fort St. John Group - Gates Formation
- Fort St. John Group - Gates, Hulcross and Boulder Creek Formations
- Fort St. John Group - Goodrich Formation
- Fort St. John Group - Hasler Formation
- Fort St. John Group - Hulcross Formation
- Fort St. John Group - Moosebar Formation
- Fort St. John Group - Sikanni Formation
- Fort St. John Group - Sully Formation
- Fort St. John Group or Smokey Group - Buckinghorse or Badheart Formation
- Dunvegan Formation
- Kotaneelee Formation
- Smokey Group - Kaskapau Formation
- Bullhead Group - Cadomin Formation
- Bullhead Group - Gething Formation
- Minnes Group
- Minnes Group - Monteith Formation
- Minnes Group - Upper Division
- Fernie Formation
- Baldonnel and Pardonet Formations
- Spray River Group
- Stoddart Group, Fantasque and Kindle Formations
- Rundle Group and Prophet Formation
- Besa River Formation
- Mount Hawk Formation
- Chushina Formation
- Lynx Formation
- Unnamed
- Gog Group
- Misinchinka Group

1:300,000 0 12 km

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Figure 4.1
Bedrock geology in the local assessment area

Date	December 7, 2012	DWG NO	1016-C14-B4979-3	R 0

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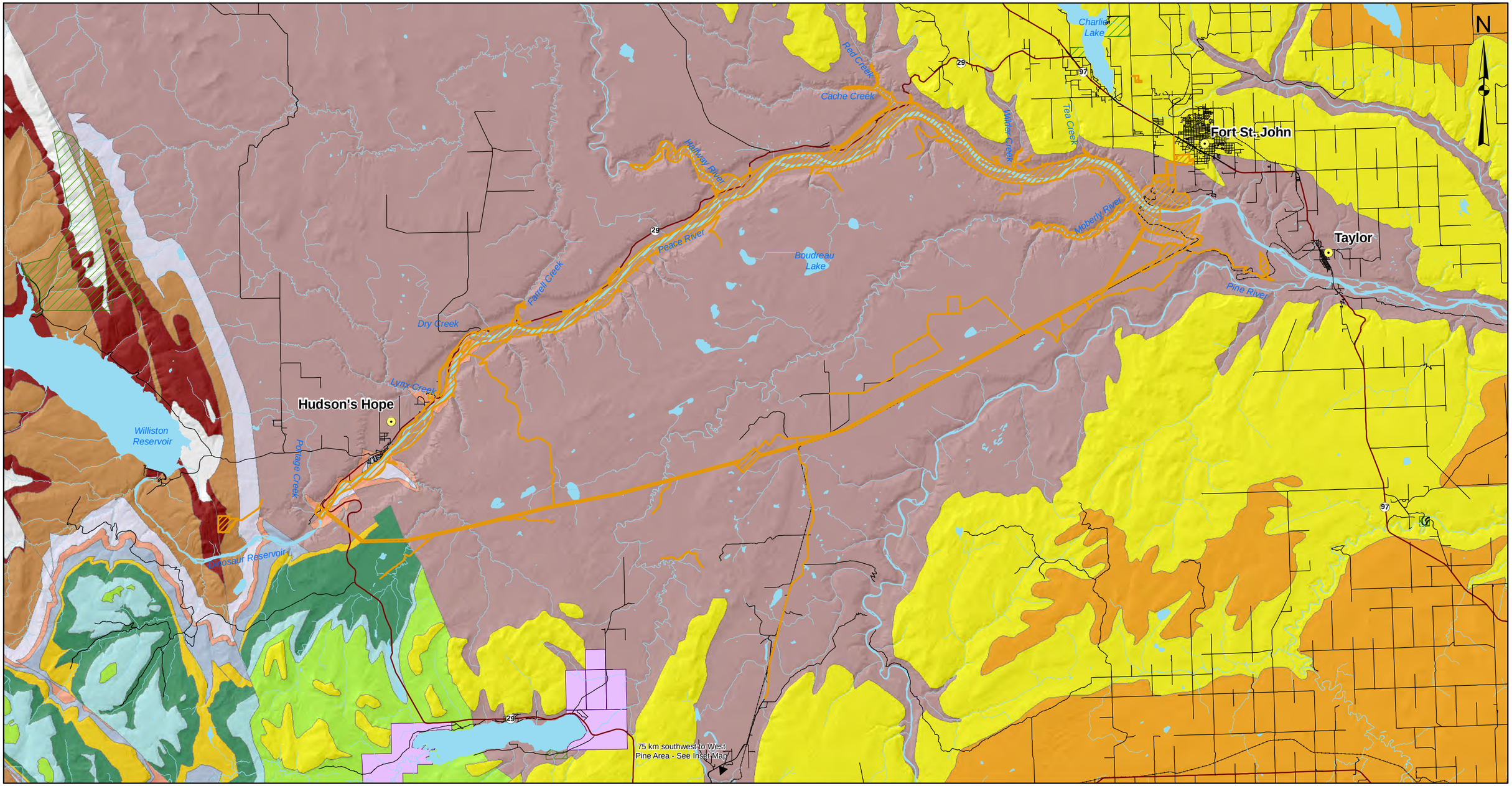

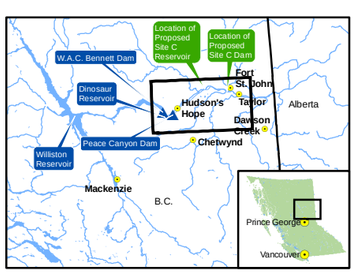

Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.
3. Geological formations (Open File 2006-13) obtained from the Ministry of Energy, Mines and Natural Gas and Resposible for Housing.

Legend

- Heritage Resources Local and Regional Assessment Area

Geological Formation
- Minnes Group (Bickford Formation
- Cadomin Formation
- Gething Formation
- Moosebar Formation
- Gates Formation
- Hulcross Formation
- Boulder Creek Formation
- Boulder Creek (Walton member)
- Hasler Formation
- Shaftsbury Formation
- Goodrich Formation
- Cruiser Formation
- Fort St. John Group (undivided)
- Dunvegan Formation
- Kaskapau Formation
- Undivided Younger Beds
- Indian Reserve
- Protected Areas, Provincial Parks, Regional Parks and Ecological Reserves.
- Existing Road
- Existing Highway
- Existing Railway
- City/District Municipality

1:300,000

0 12 km

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Figure 4.2
Surficial geology in the local assessment area

Date	December 7, 2012	DWG NO	1016-C14-B4979-4	R 0

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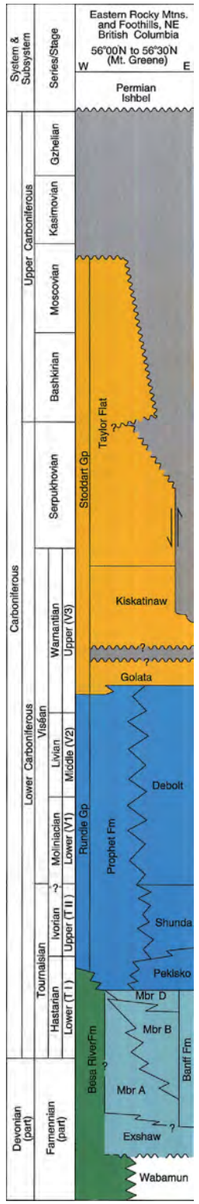
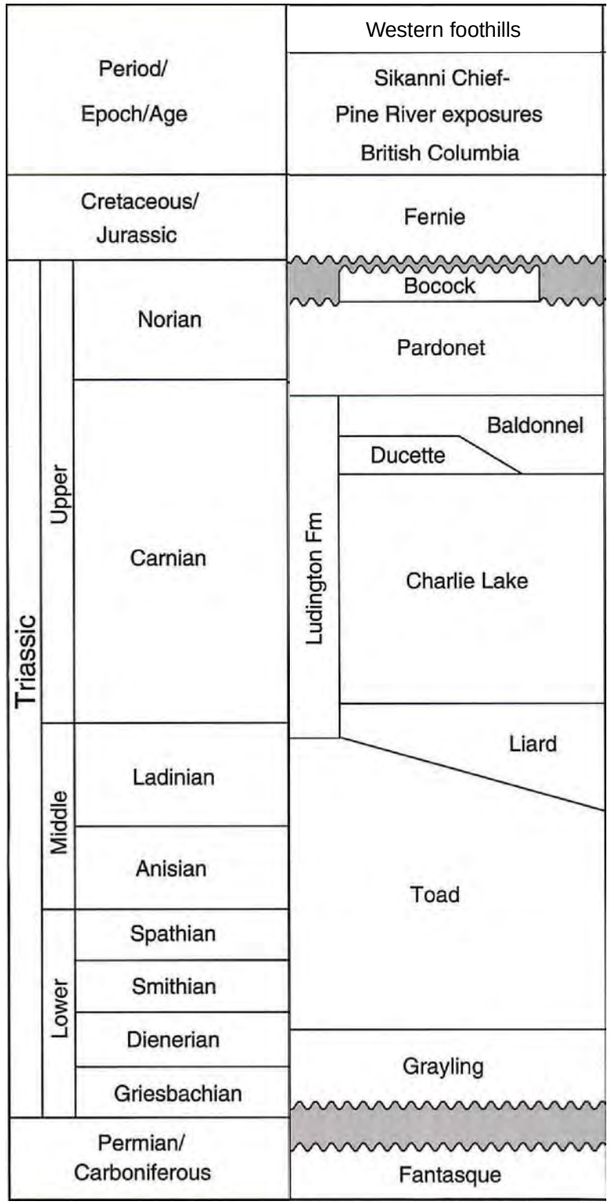
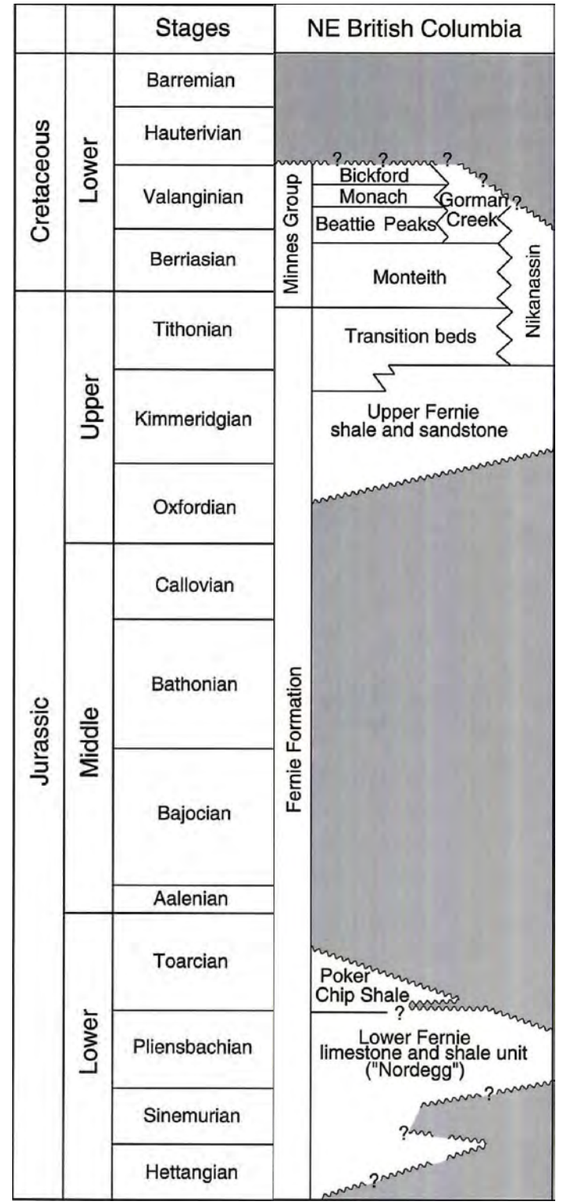


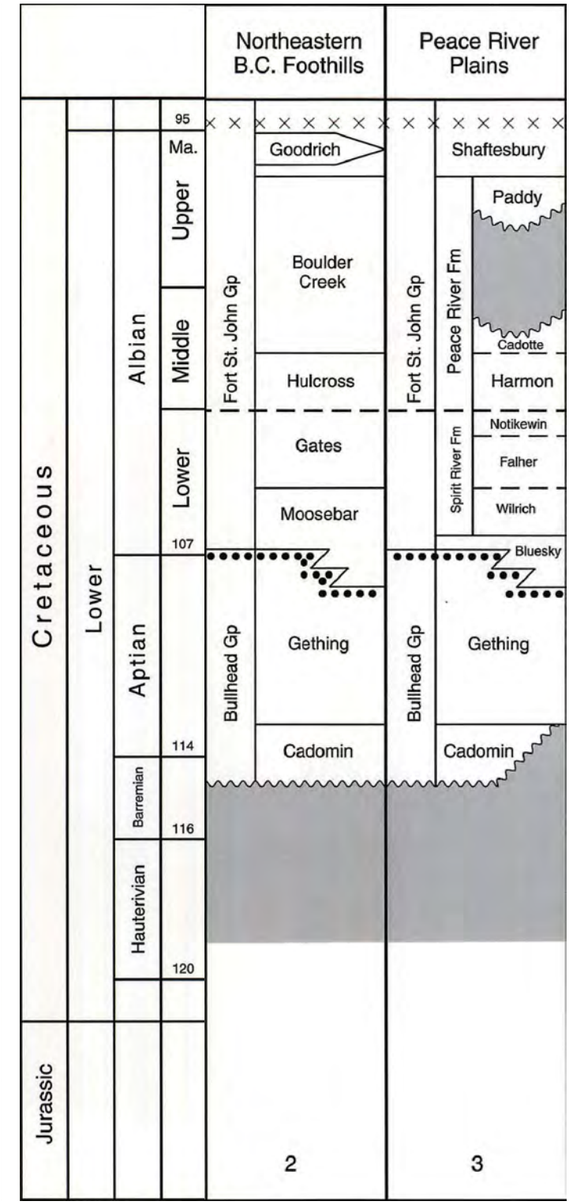
A. Stratigraphic column of the Carboniferous (Richards et al. 1994)



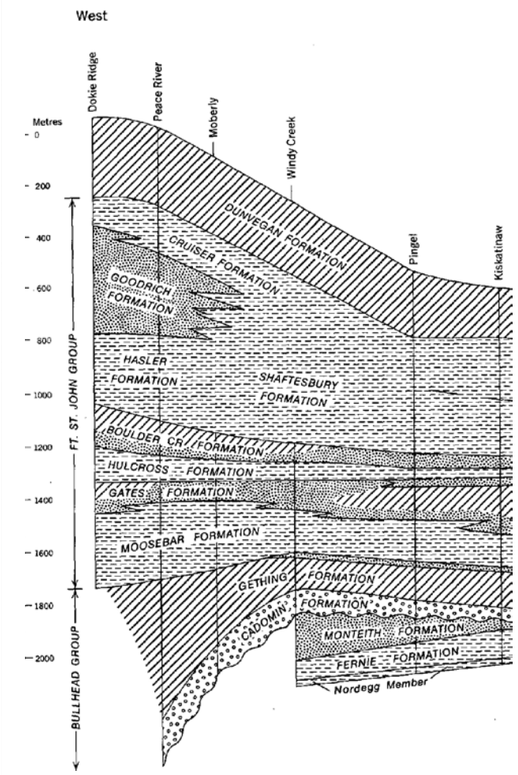
B. Stratigraphic column of the Triassic (Edwards et al. 1994)



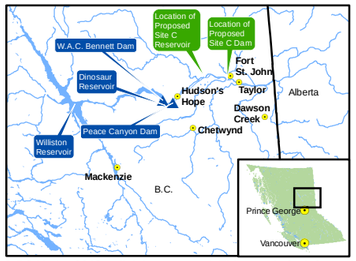
C. Stratigraphic column of the Jurassic to Lowest Cretaceous (Poutlton et al. 1994)



D. Stratigraphic column of the Lower Cretaceous (Hayes et al. 1994)



E. Schematic stratigraphic cross-section across the Peace River region (Stott 1982)



Map Notes:
1. Stratigraphic columns obtained from the Alberta Geological Survey.

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Figure 4.3
Stratigraphic columns

Date	December 7, 2012	DWG NO		R 0

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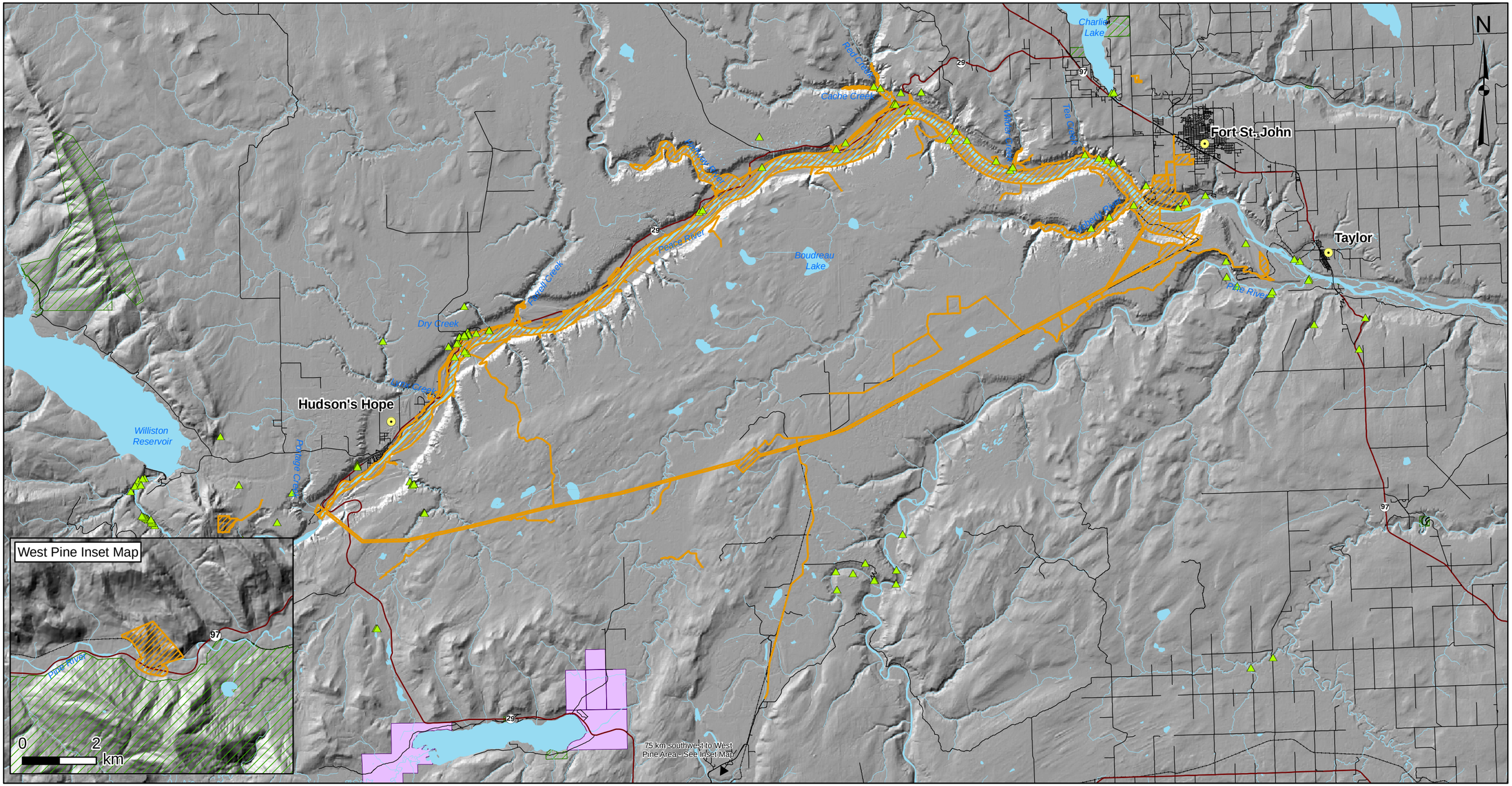

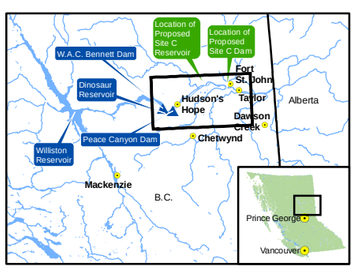

Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

Legend

- Heritage Resources Local and Regional Assessment Area
- Previously Documented Palaeontological Site
- Protected Areas, Provincial Parks, Regional Parks and Ecological Reserves.
- Indian Reserve
- City/District Municipality
- Existing Road
- Existing Highway
- Existing Railway

1:300,000

0 12 km

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Figure 4.4
Previously documented palaeontological sites

Date	Dec 7, 2012	DWG NO	1016-C14-B4979-6	R 0

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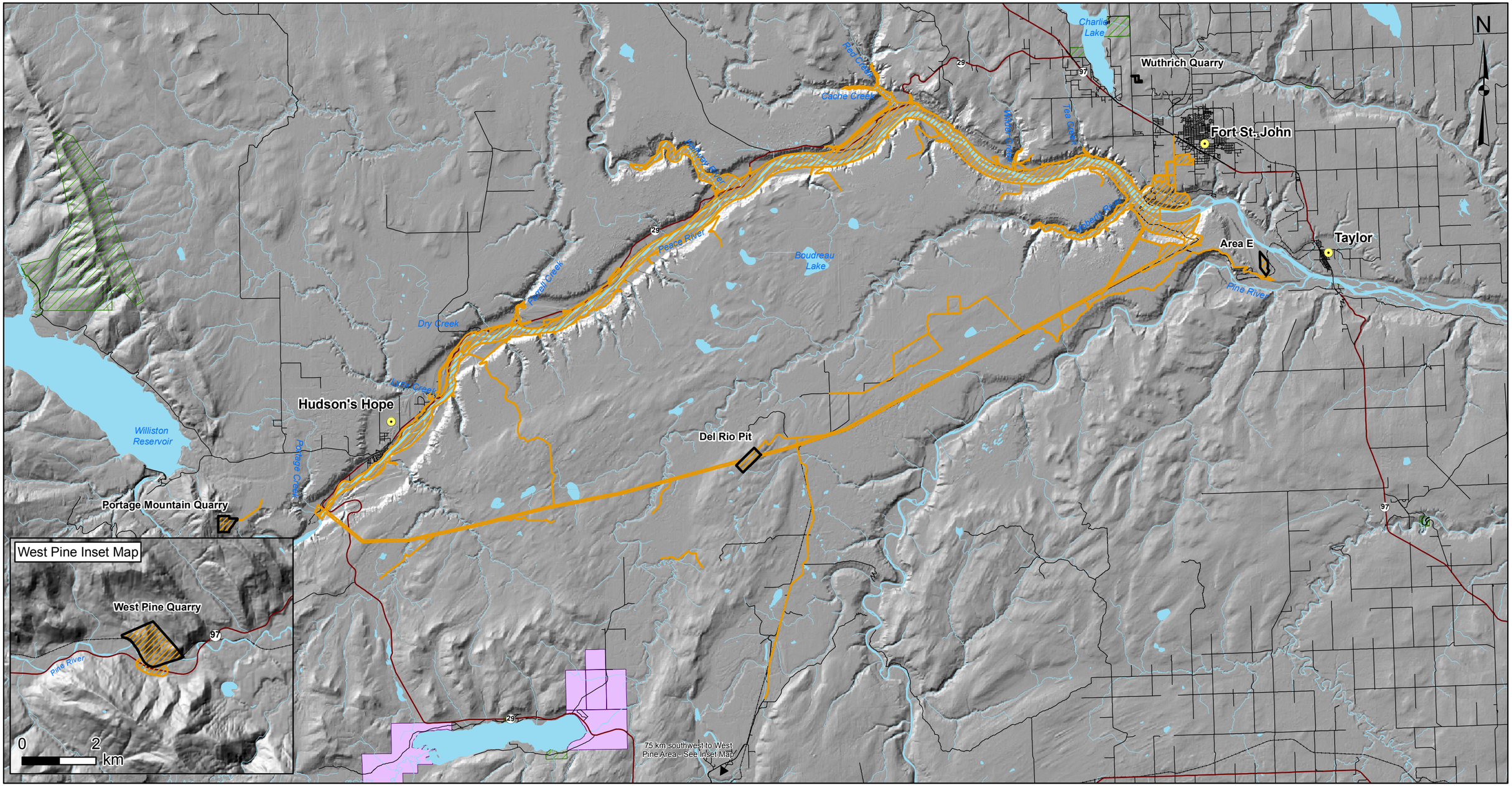
The following figures contain sensitive information that has been redacted from the public version of the Site C Clean Energy Project Environmental Impact Statement:

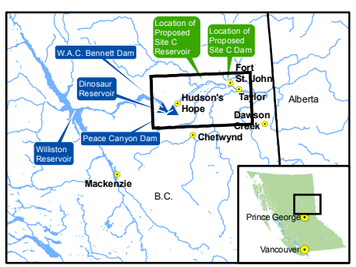
Figures 5.6 through 5.13

Figure 5.16

Figure 5.19

Figures 5.27 through 5.30





Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

Legend

- Heritage Resources Local and Regional Assessment Area
- Offsite Construction Materials Proposed Source
- Protected Areas, Provincial Parks, Regional Parks and Ecological Reserves.
- Indian Reserve
- City/District Municipality
- Existing Road
- Existing Highway
- Existing Railway

1:300,000

0 12 km

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Figure 5.1
Archaeological overview assessment areas

Date	December 7, 2012	DWG NO	1016-C14-B4978-09	R 0

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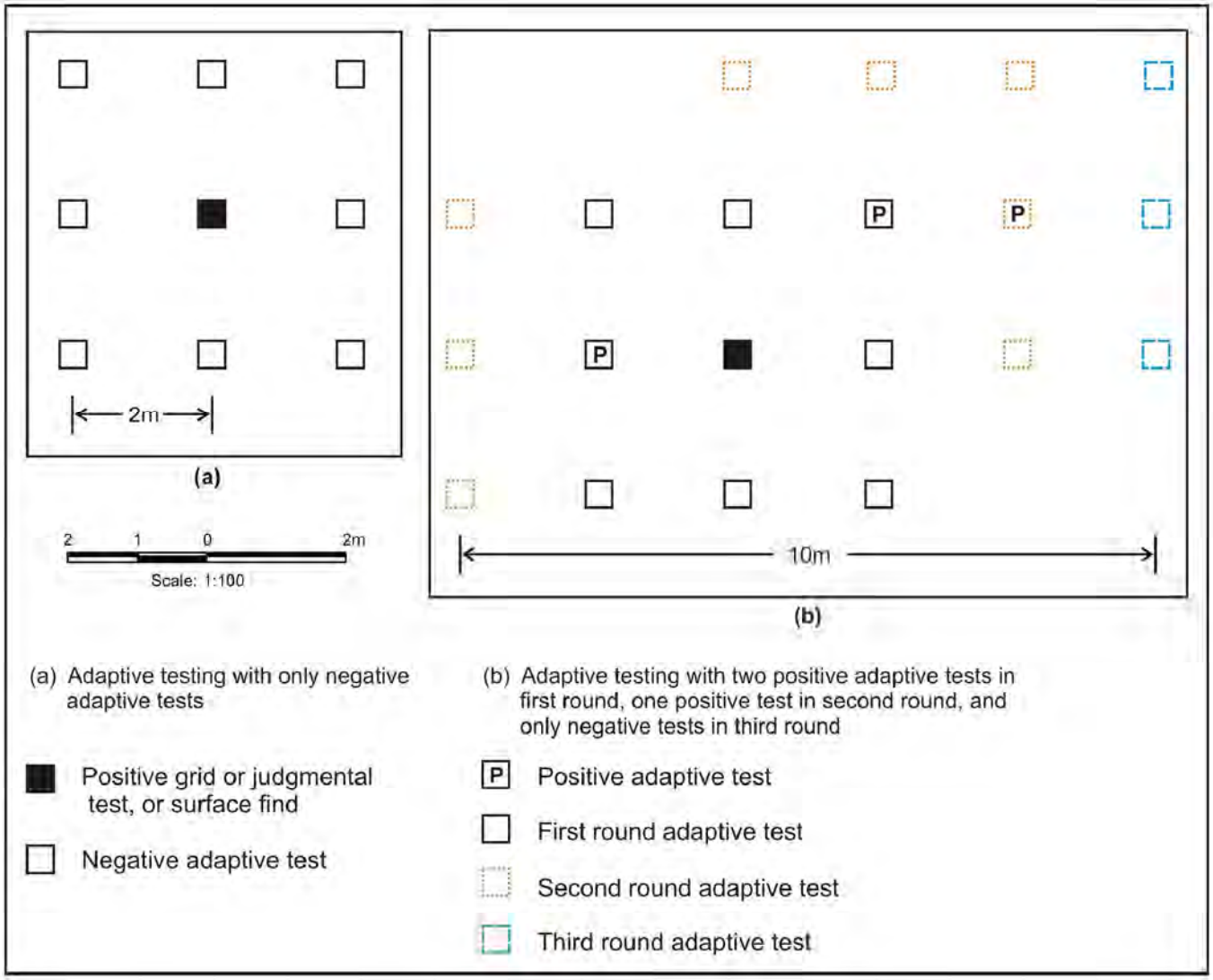

NOT TO SCALE

SITE C CLEAN ENERGY PROJECT		BC hydro / Golder Associates	
		Figure 5.2 **Adaptive testing**	
DATE	December 7, 2012	1016-C14-A4979-09	R 0

Map Notes:
1. Department of the Interior 1916b.

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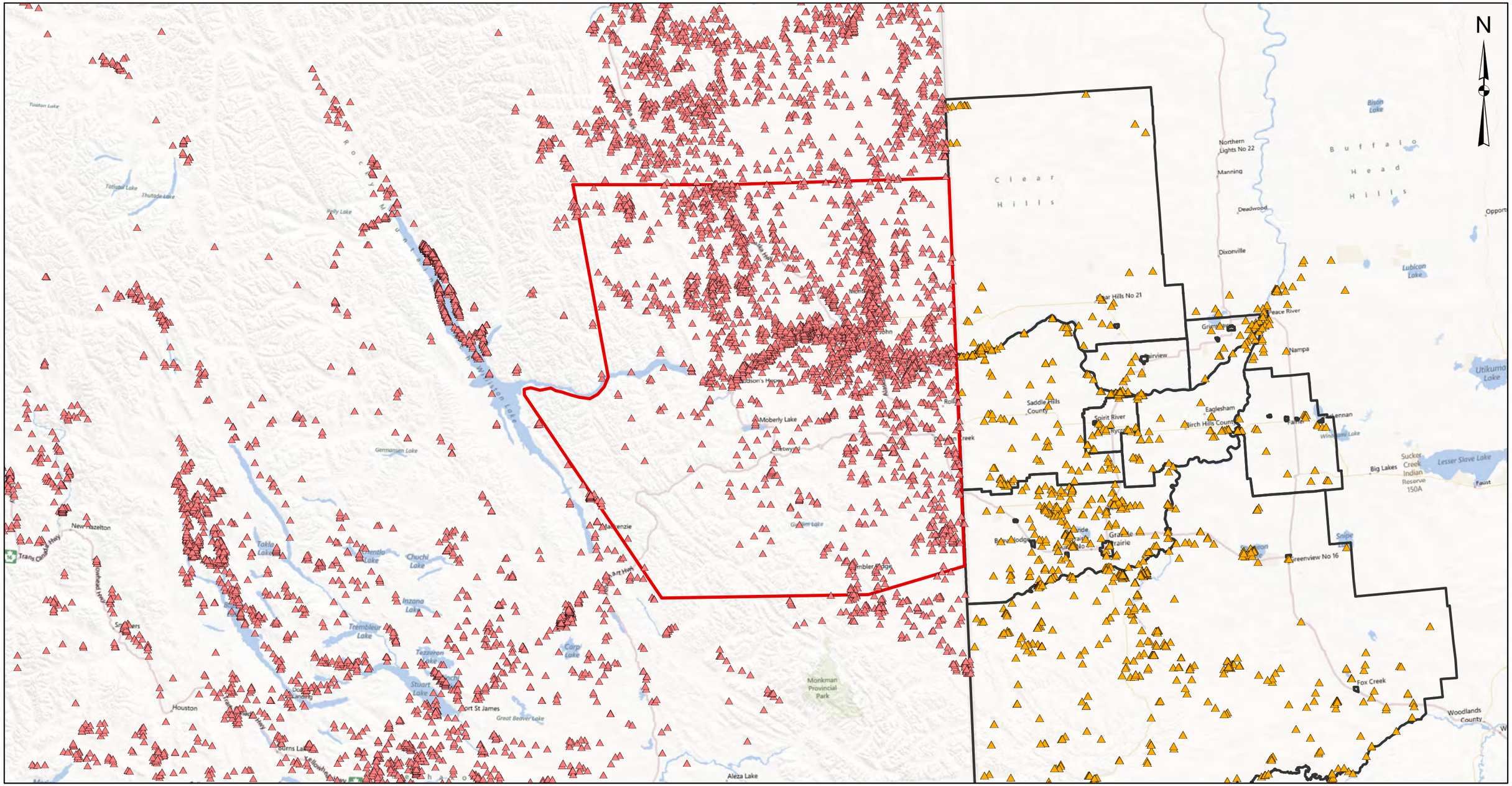

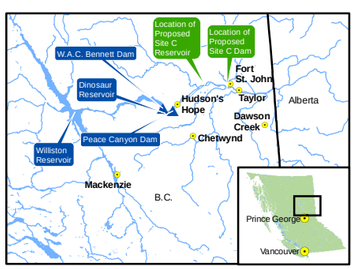

Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Base data obtained from BING Maps for ArcGIS published by Microsoft Corporation, Redmond, WA, May 2009.
3. Previously Recorded Archeological Sites Obtained from RAAD (October 13, 2012)

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Legend

- HCA Inspection Permit 2010-0378 (amended area)
- AB Management Districts
- BC Archaeological Site
- AB Archaeological Site

1:2,000,000

0 80 km

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Figure 5.3
Archaeological sites in the Peace region of BC and Alberta

Date	December 7, 2012	DWG NO	1016-C14-B4979-11	R 0

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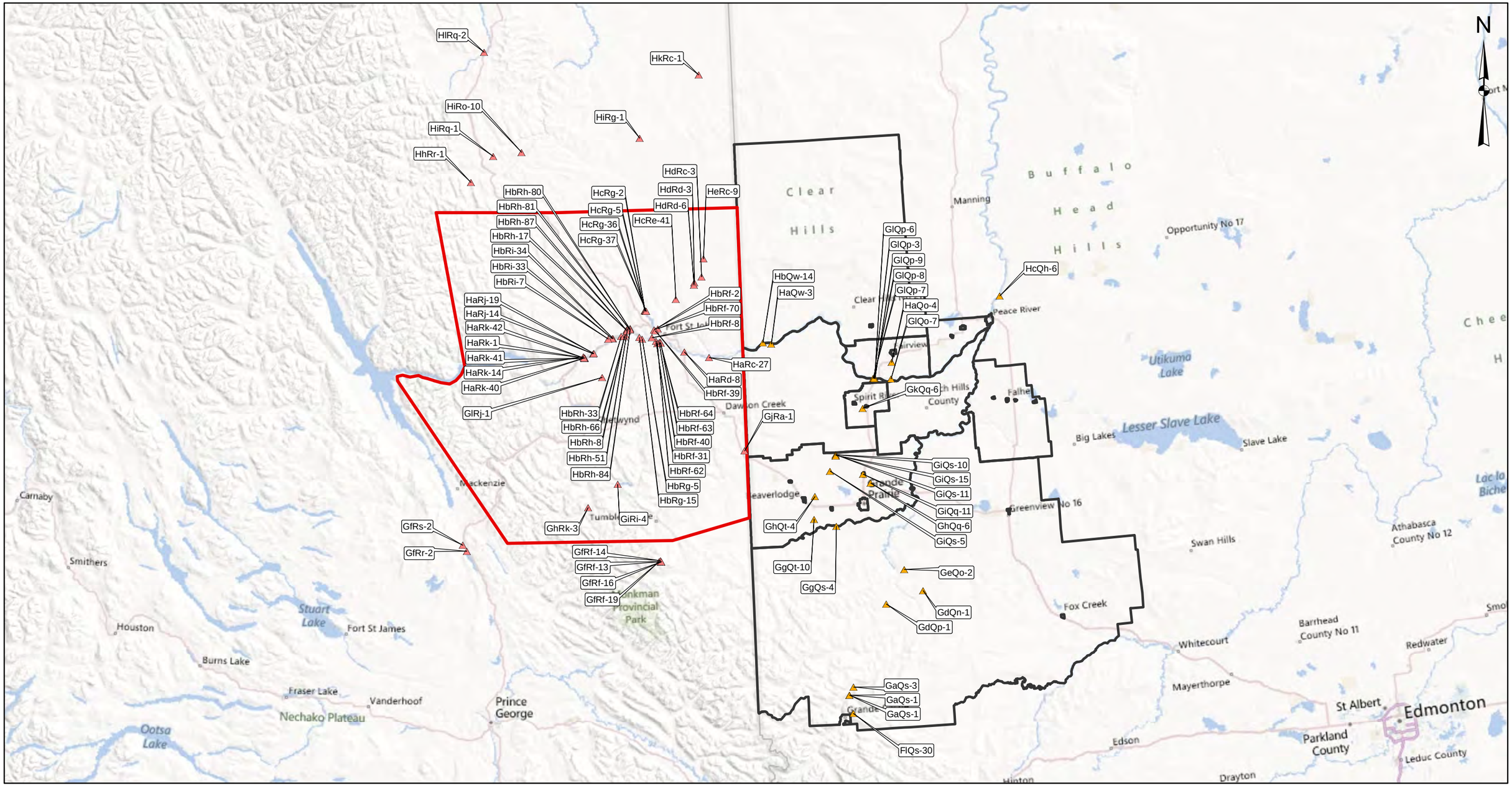

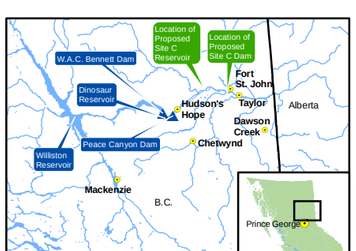

Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Base data obtained from BING Maps for ArcGIS published by Microsoft Corporation, Redmond, WA, May 2009.
3. Previously Recorded Archeological Sites Obtained from RAAD (October 13, 2012)

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Legend

- HCA Inspection Permit 2010-0378 (amended area)
- AB Management Districts
- BC Excavated Site
- AB Excavated Site

1:2,500,000

0 100 km

SITE C CLEAN ENERGY PROJECT

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Figure 5.4
Investigated archaeological sites in northeastern BC and northwestern Alberta

Date	December 7, 2012	DWG NO	1016-C14-B4979-12	R 0

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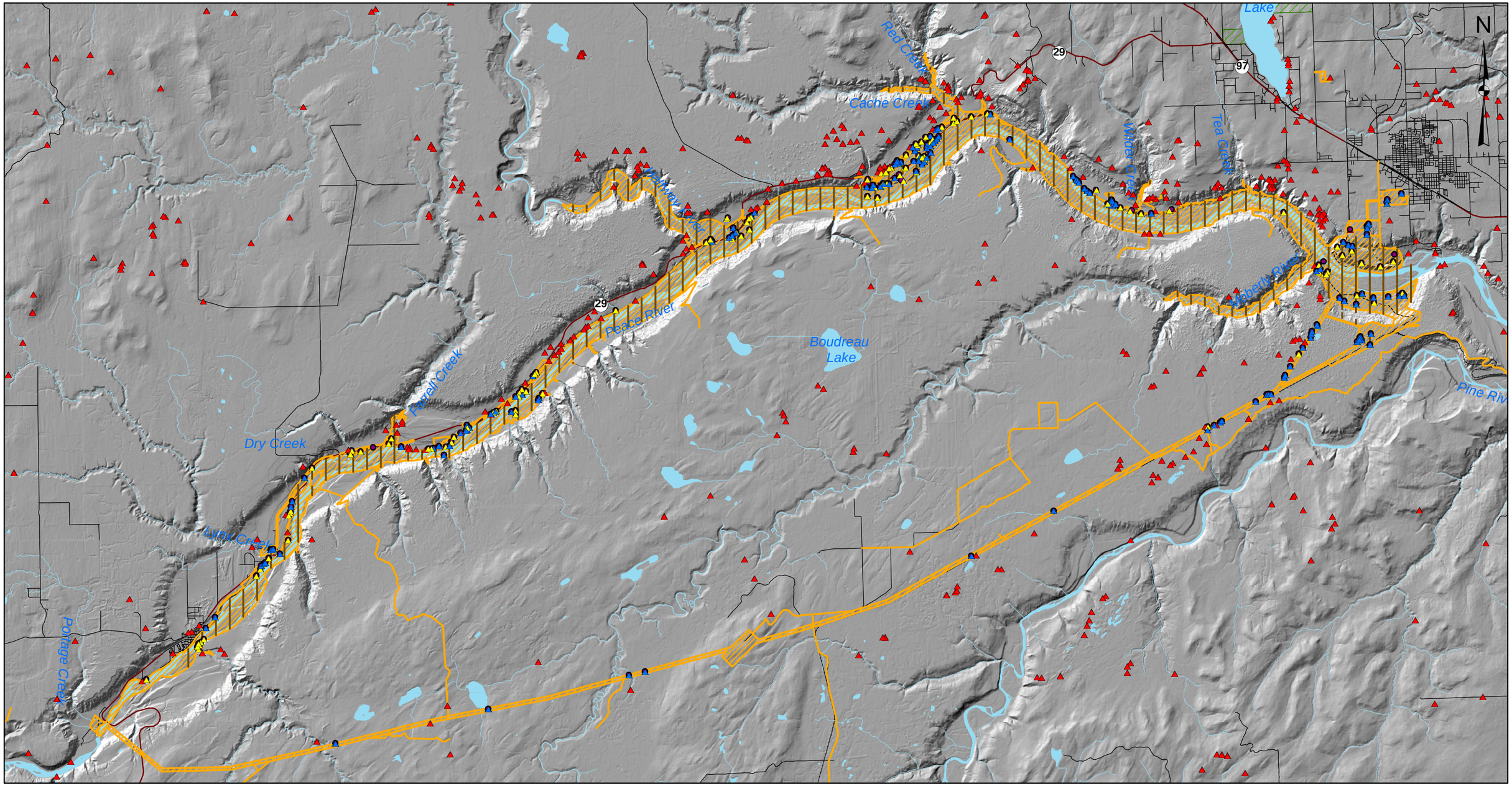

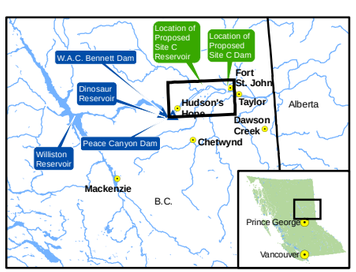

Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

Legend

- Heritage Resources Local and Regional Assessment Area
- Transect
- Newly Recorded Archaeological Site Within the Study Areaa
- Archaeological Site Outside the Study Area
- Archaeological Site Within the Study Area
- Indian Reserve
- Protected Areas, Provincial Parks, Regional Parks and Ecological Reserves.
- Existing Road
- Existing Highway
- Existing Railway

1:200,000

0 8 km

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Figure 5.5
Model testing survey transects

Date	December 7, 2012	DWG NO	1016-C14-B4979-13	R 0

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Fort St. John

Taylor

Hudson's Hope

Charlie Lake

Boudreau Lake

Williston Reservoir

Pine River

Dry Creek

Cache Creek

Red Creek

Tea Creek

Moberly Creek

Boudreau Creek

Peacock Creek

Portage Creek

Hart Creek

29

97

75 km southwest to West Pine Area - See Inset Map

West Pine Inset Map

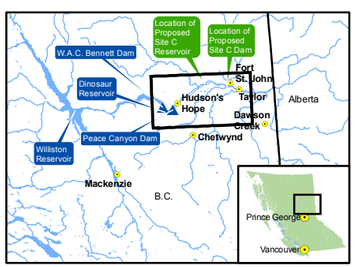
Hwy 97

0 2 km

N

Legend

- Heritage Resources Local and Regional Assessment Area
- Test Location
- Protected Areas, Provincial Parks, Regional Parks and Ecological Reserves.
- Indian Reserve
- City/District Municipality
- Existing Road
- Existing Highway
- Existing Railway



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

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1:300,000

0 12 km

SITE C CLEAN ENERGY PROJECT

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Figure 5.14
Archaeological test locations

Date	December 7, 2012	DWG NO	1016-C14-B4979-22	R 0

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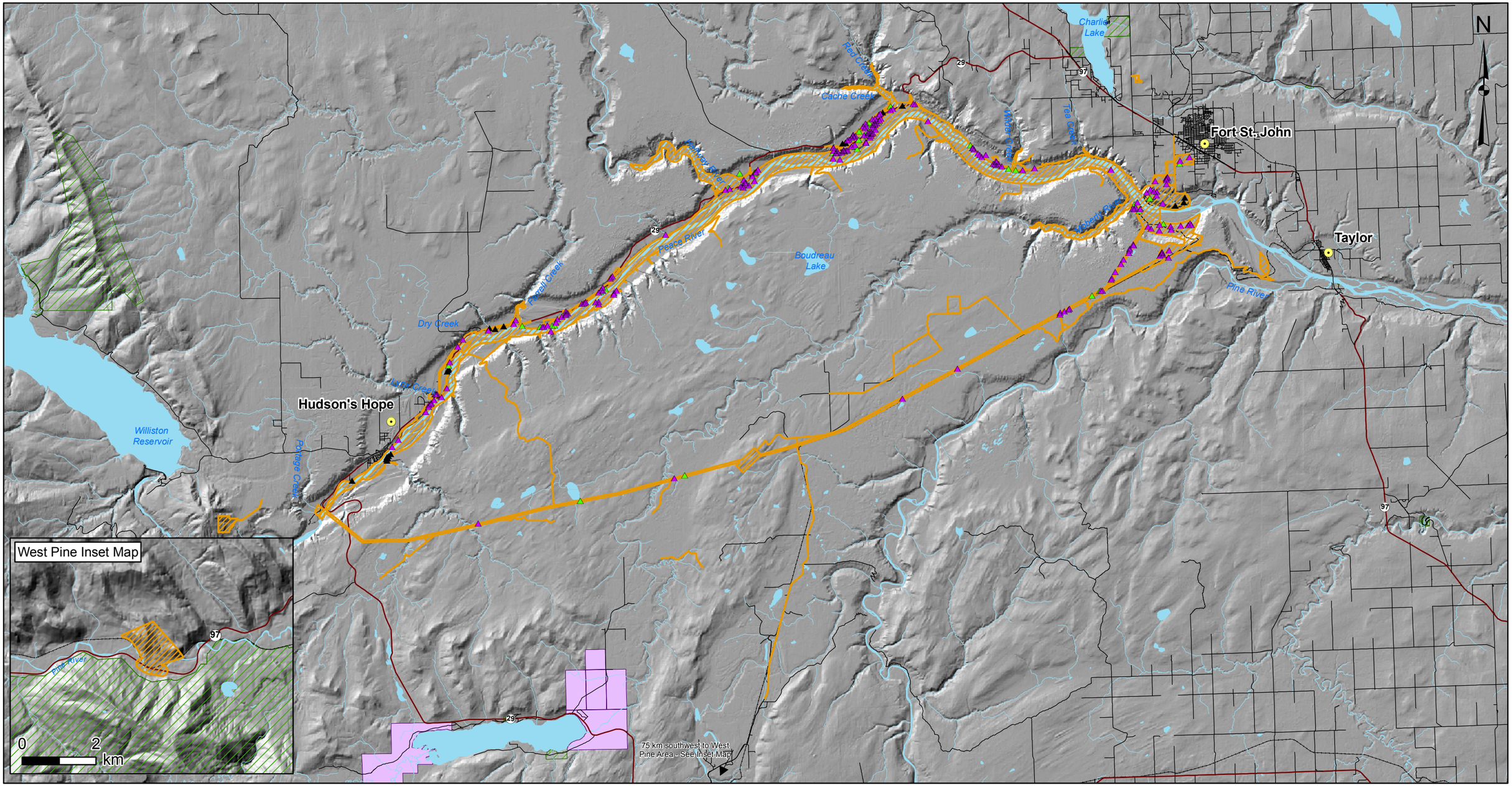

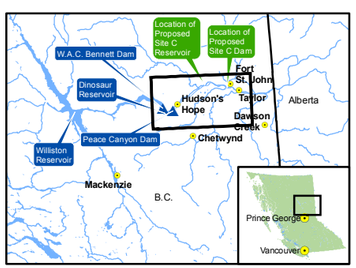

Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

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Legend

- Heritage Resources Local and Regional Assessment Area

Archaeological Site

- Class I
- Class II
- Not Assessed
- Protected Areas, Provincial Parks, Regional Parks and Ecological Reserves.
- Indian Reserve
- City/District Municipality
- Existing Road
- Existing Highway
- Existing Railway

1:300,000

0 12 km

SITE C CLEAN ENERGY PROJECT

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Figure 5.15
Archaeological sites

Date	December 7, 2012	DWG NO	1016-C14-B4979-23	R 0

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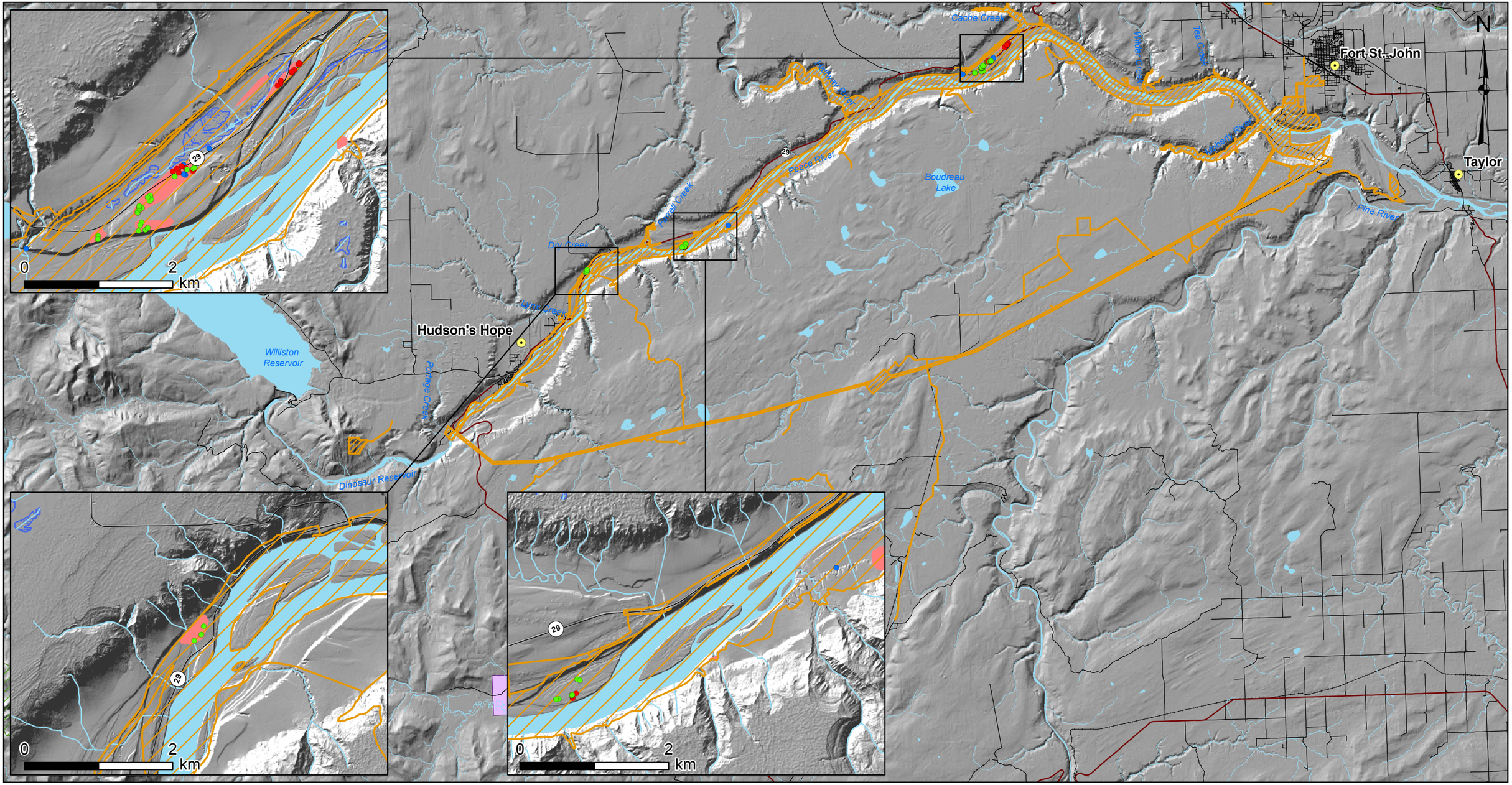

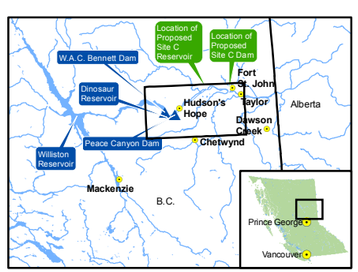

Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

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Legend

- Heritage Resources Local and Regional Assessment Area
- Deep Testing Location
  - Auger Test
  - Backhoe
  - Evaluative Unit
  - Deep Testing Model
  - Indian Reserve
- City/District Municipality
- Existing Road
- Existing Highway
- Existing Railway

1:300,000

0 12 km

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Figure 5.17
Deep testing locations

Date	December 7, 2012	DWG NO	1016-C14-B4979-25	R 0

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Watson Slough Inset Map

0 2 km

Boucher Lake Inset Map

0 0.4 km

N

Fort St. John

Taylor

Hudson's Hope

Charlie Lake

Cache Creek

Red Creek

Tea Creek

Moberly Lake

Moberly River

Peace River

Boudreau Lake

Pine River

Dry Creek

Farrell Creek

Lynx Creek

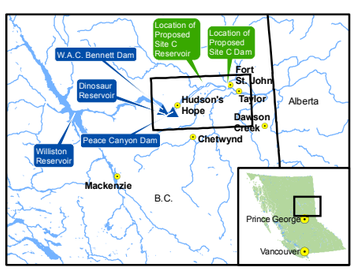
Pouce Coupe River

Williston Reservoir

Dinosaur Reservoir

29

97



Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

Legend

- Heritage Resources Local and Regional Assessment Area
- Subsurface Test
  - Positive
  - Negative
  - NA
- Indian Reserve
- Protected Areas, Provincial Parks, Regional Parks and Ecological Reserves.
- City/District Municipality
- Existing Road
- Existing Highway
- Existing Railway

1:300,000

0 12 km

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Figure 5.18
Wetland testing locations

Date	December 7, 2012	DWG NO	1016-C14-B4979-26	R 0

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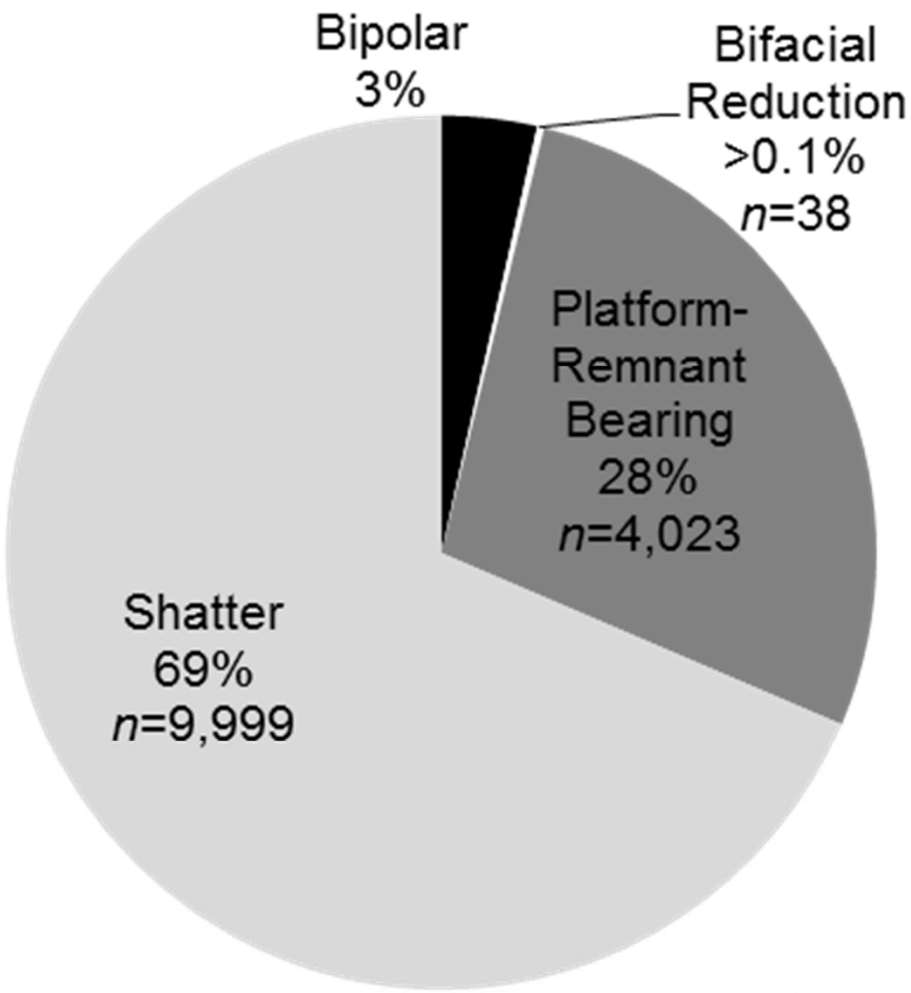

Figure 5.20 Frequency of debitage classes from sites throughout the local assessment area

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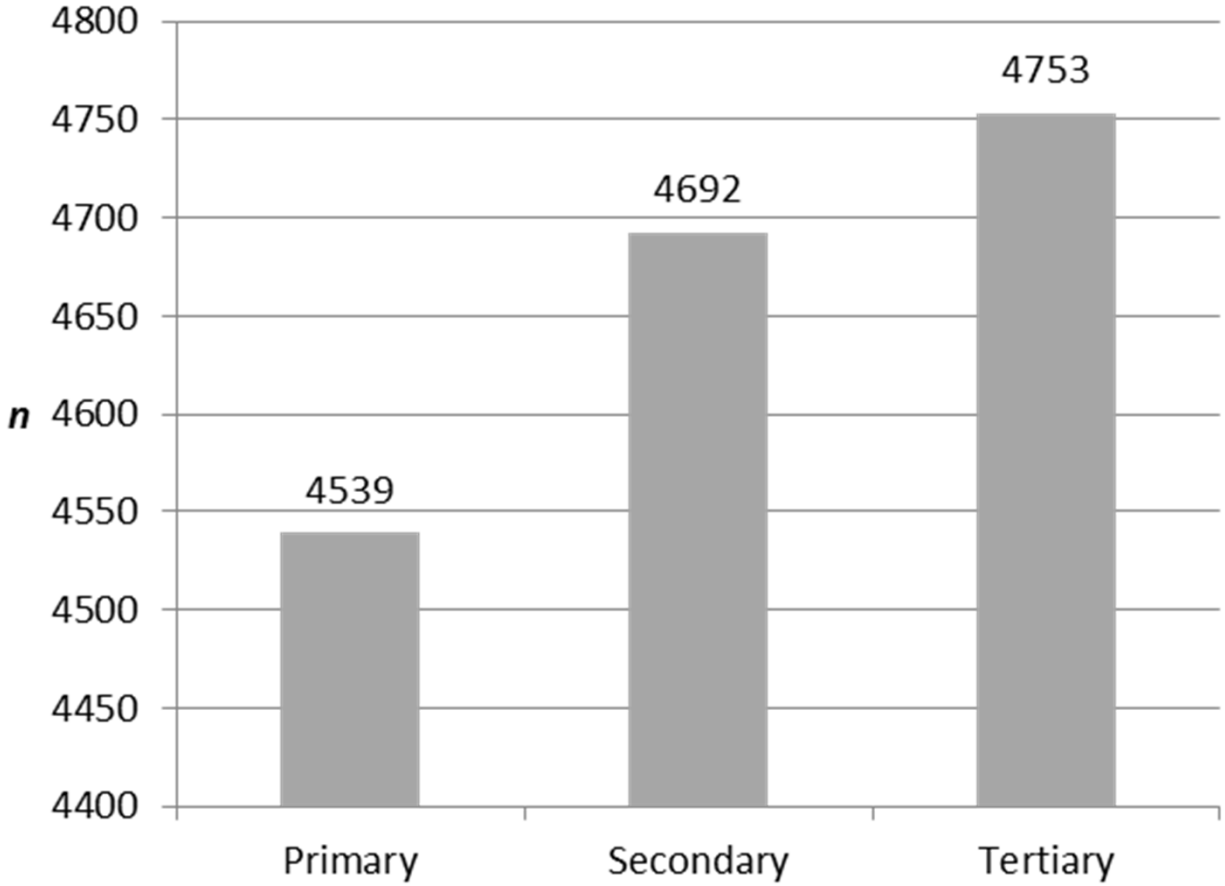

Figure 5.21 Frequency of reduction stages in debitage assemblage from sites throughout the local assessment area

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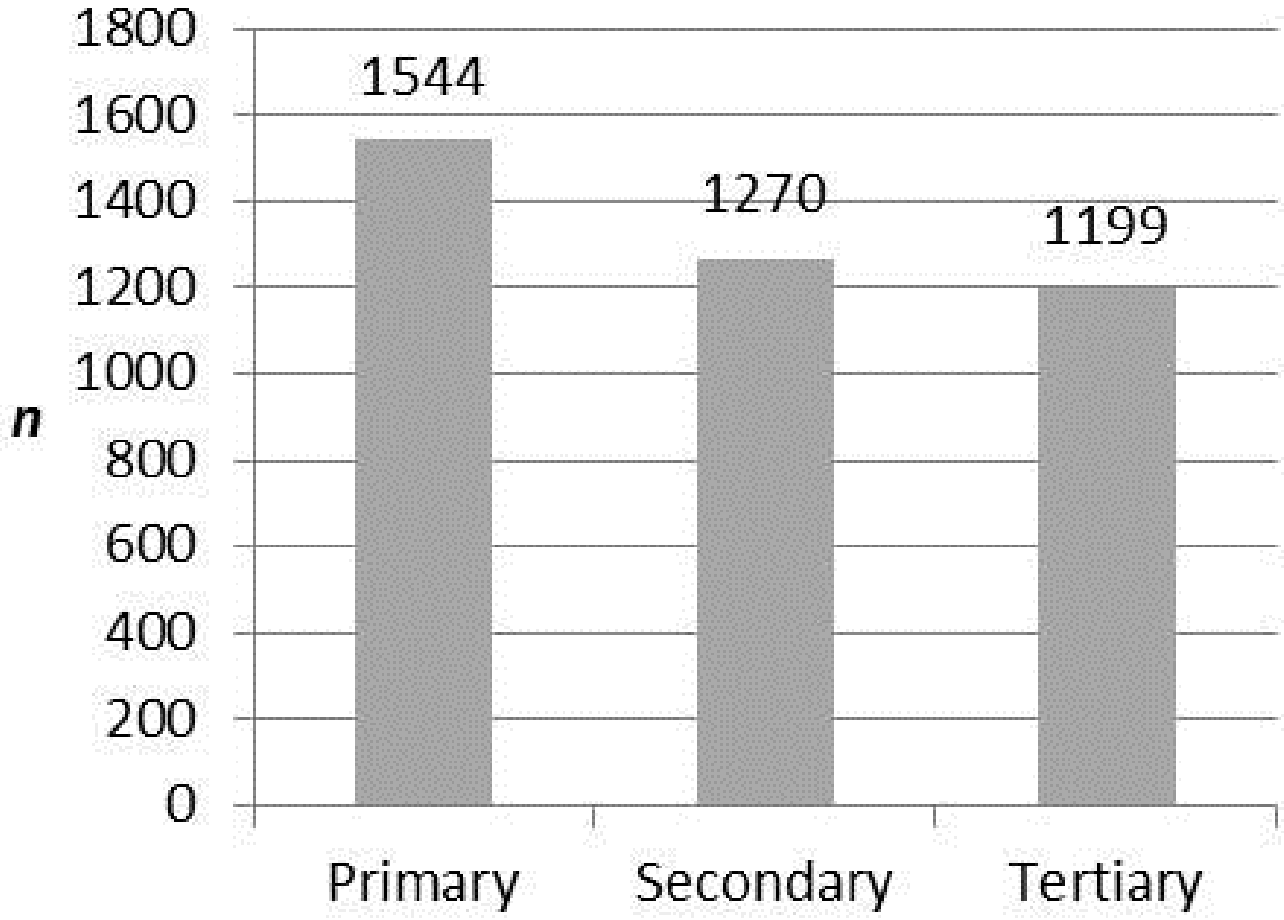

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SITE C CLEAN ENERGY PROJECT

Figure 5.22 Frequency of reduction stages in platform remnant-bearing debitage from sites throughout the local assessment area

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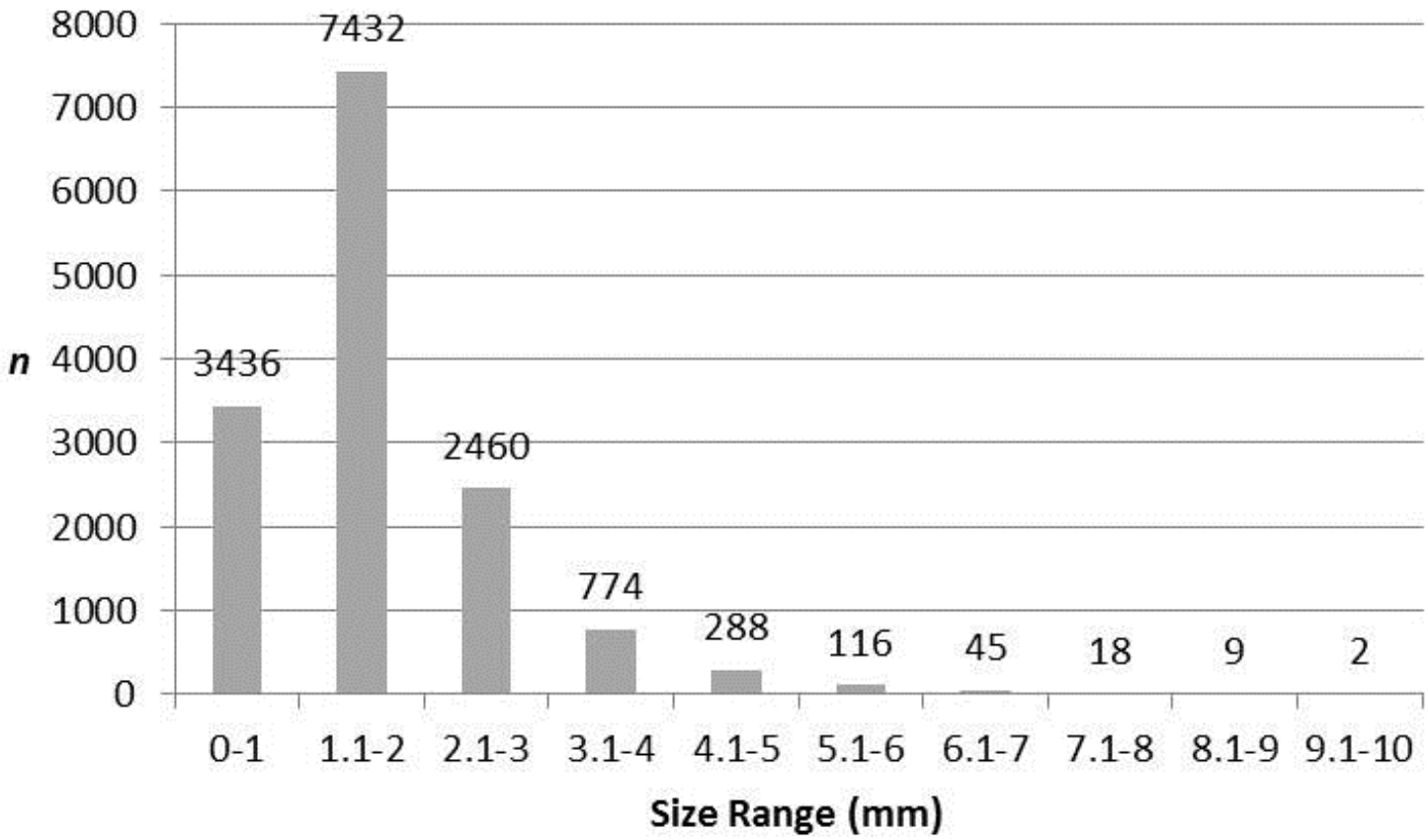

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SITE C CLEAN ENERGY PROJECT

Figure 5.23 Frequency of size classes in debitage assemblage from sites in the local assessment area

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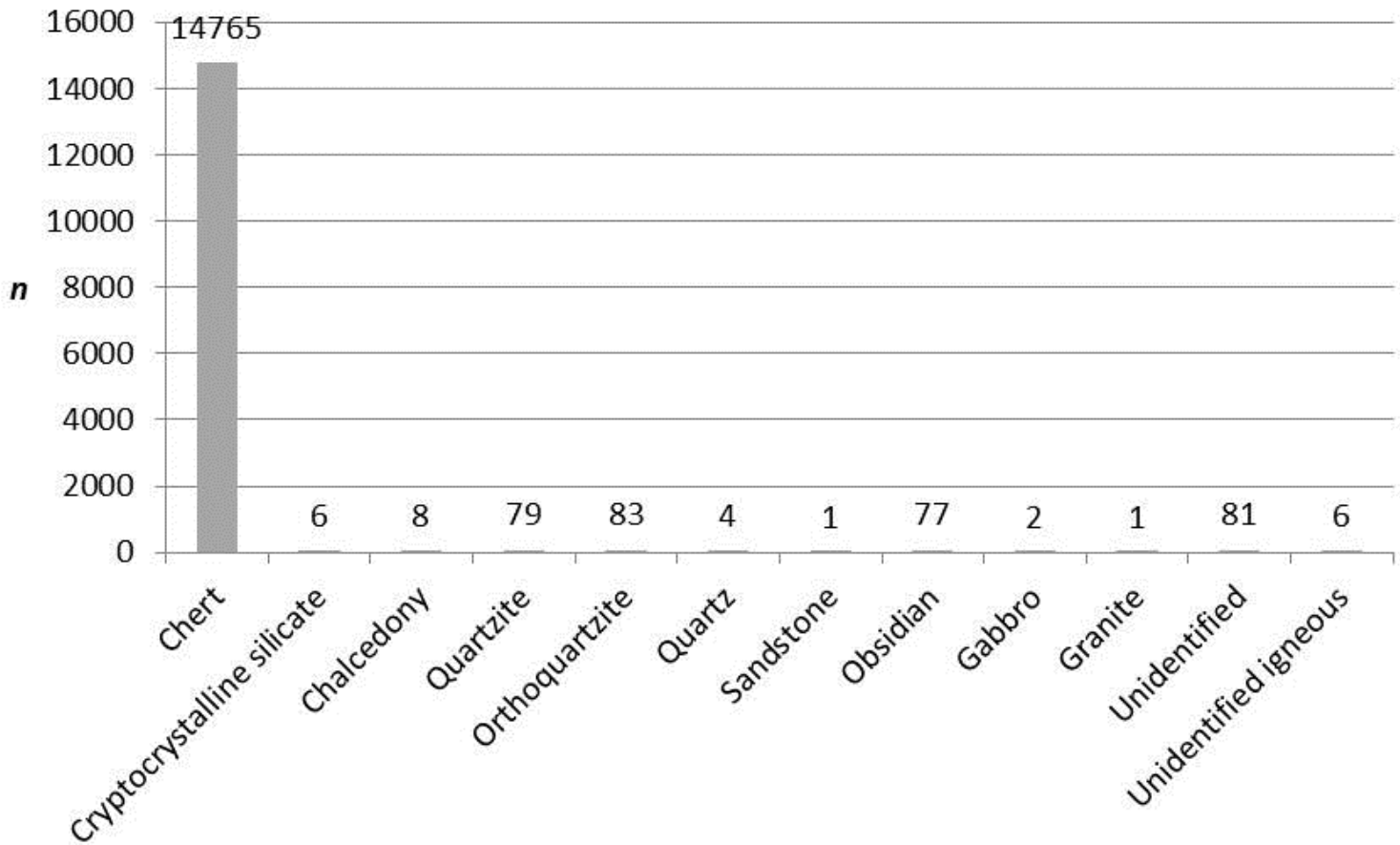

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SITE C CLEAN ENERGY PROJECT

Figure 5.24 Frequency of lithic raw material types from sites in the local assessment area

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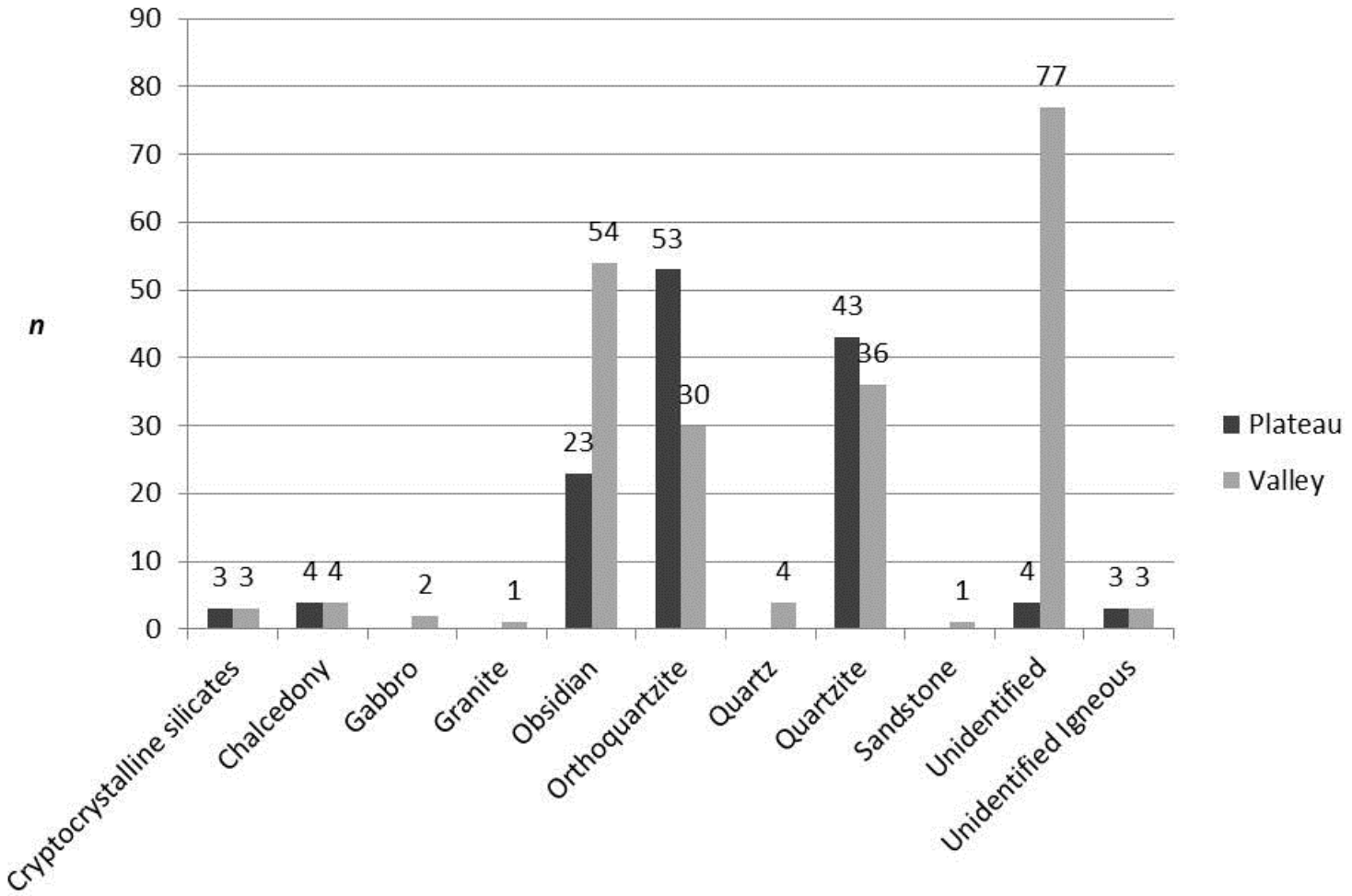

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SITE C CLEAN ENERGY PROJECT

Figure 5.25 Comparison of non-chert lithic raw material frequencies in plateau and valley site assemblages

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MT. EDZIZA VOLCANIC FIELD

ANAHIM ILGACHUZ

BEAR GULCH

BRITISH COLUMBIA

ALBERTA

SASKATCHEWAN

MONTANA

WASHINGTON

IDAHO

OREGON

Edmonton

Calgary

Prince George

Kelowna

Spokane

Helena

Billings

Kennewick

Salem

Boise

Idaho Falls

Medicine Hat

Queen Charlotte Sound

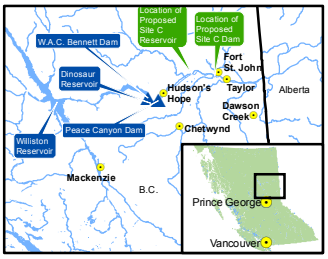
Hecate Strait

Cascadia Basin

Blanco Fracture Zone

Legend

- Obsidian Source
- Site C Clean Energy Project
- Provincial/Territorial/State Boundary



Map Notes:
1. Datum: NAD83
2. Projection: BC Albers
3. Base Data: ESRI

1:10,000,000 0 400 Km

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SITE C CLEAN ENERGY PROJECT

Figure 5.26
Sources of obsidian identified at archaeological sites in the local assessment area

DATE	December 7, 2012	1016-C14-A4979-2	R 0

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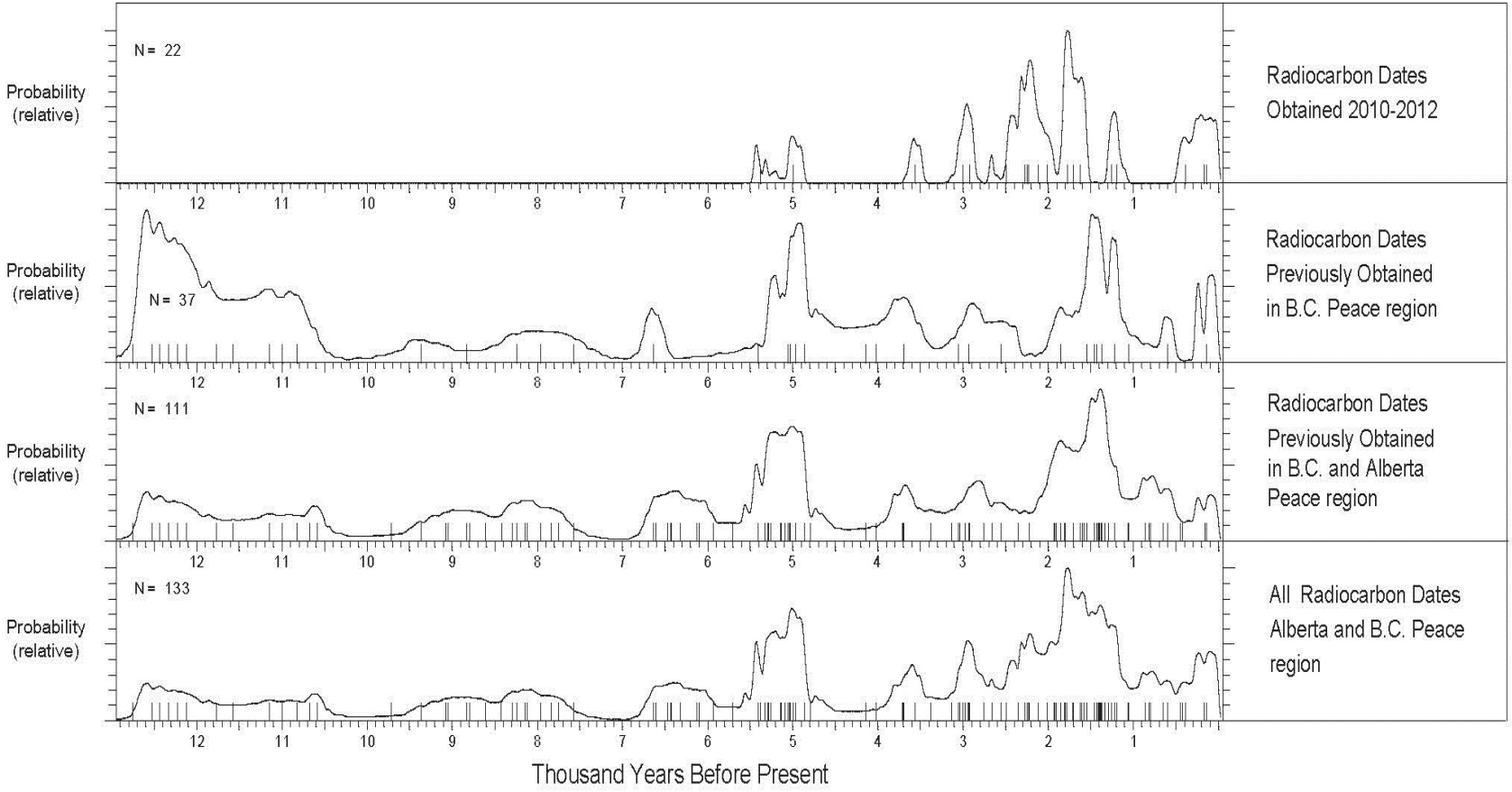

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SITE C CLEAN ENERGY PROJECT

Figure 5.31 Relative probability of calibrated radiocarbon dates in the Peace region

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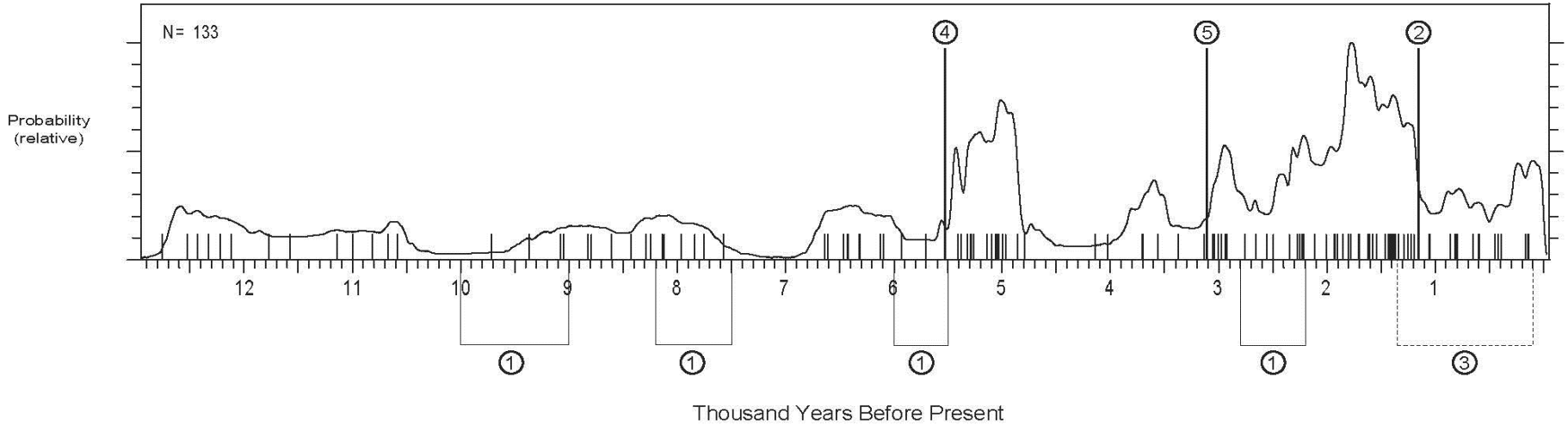

1. Forest fire peaks
2. White River ash fall
3. Little Ice Age
4. Start of moister and more moderate climatic conditions
5. Modern vegetation established

NOTES:
SEE SECTION 3.1.8.2 FOR CLIMATIC REFERENCES, PLOTTED USING CALPAL SOFTWARE (WENINGER AND DANZEGLOCKE 2012)

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SITE C CLEAN ENERGY PROJECT

Figure 5.32 Comparison of calibrated radiocarbon dates and climatic events

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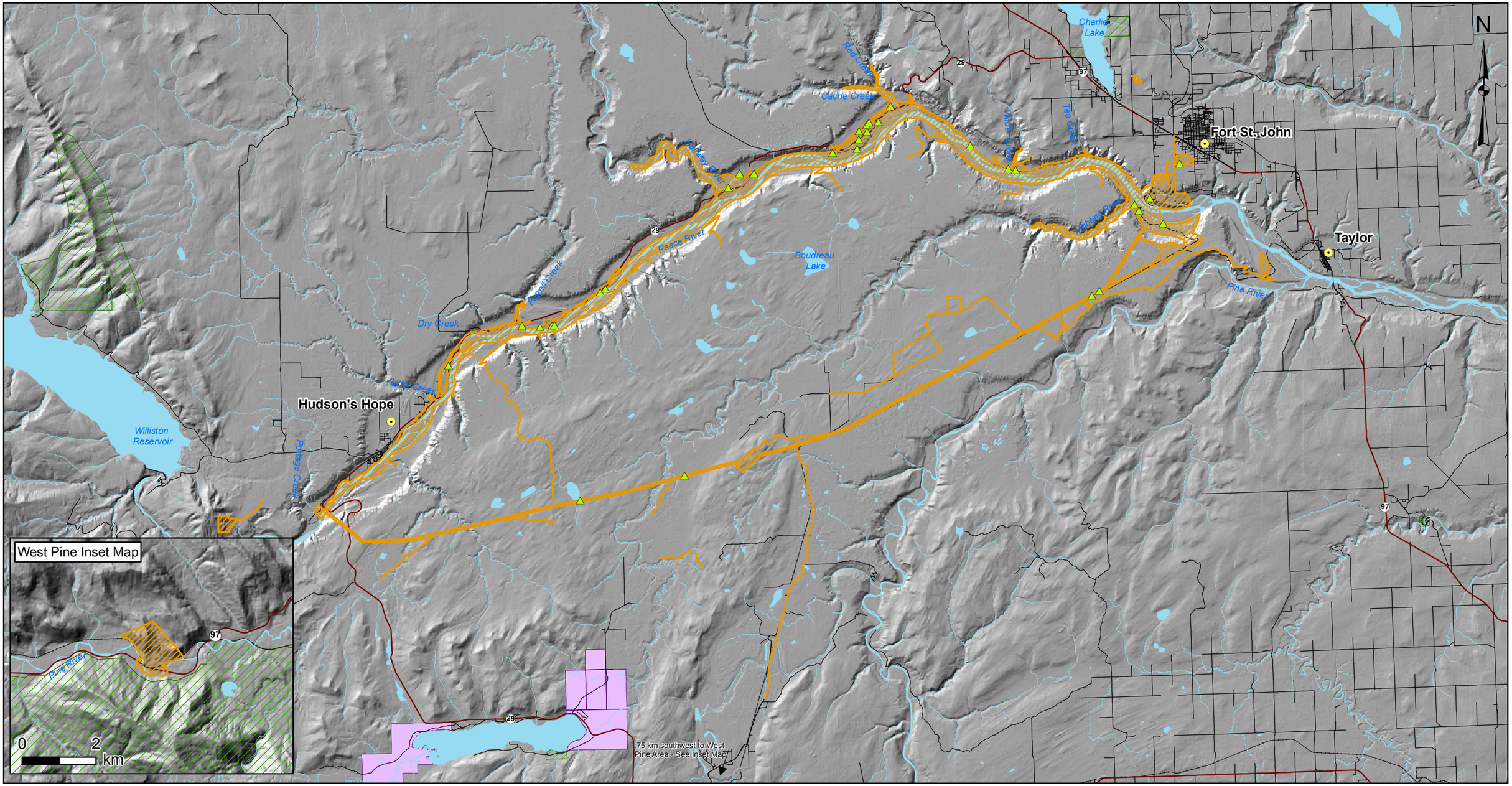

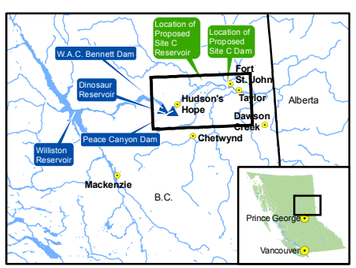

Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

Legend

- Heritage Resources Local and Regional Assessment Area
- Archaeological Site
  - Class I
- Indian Reserve
- Protected Areas, Provincial Parks, Regional Parks and Ecological Reserves.
- Existing Road
- Existing Highway
- Existing Railway
- City/District Municipality

1:300,000

0 12 km

SITE C CLEAN ENERGY PROJECT

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Figure 5.33
Class I archaeological sites

Date	December 7, 2012	DWG NO	1016-C14-B4979-80	R 0

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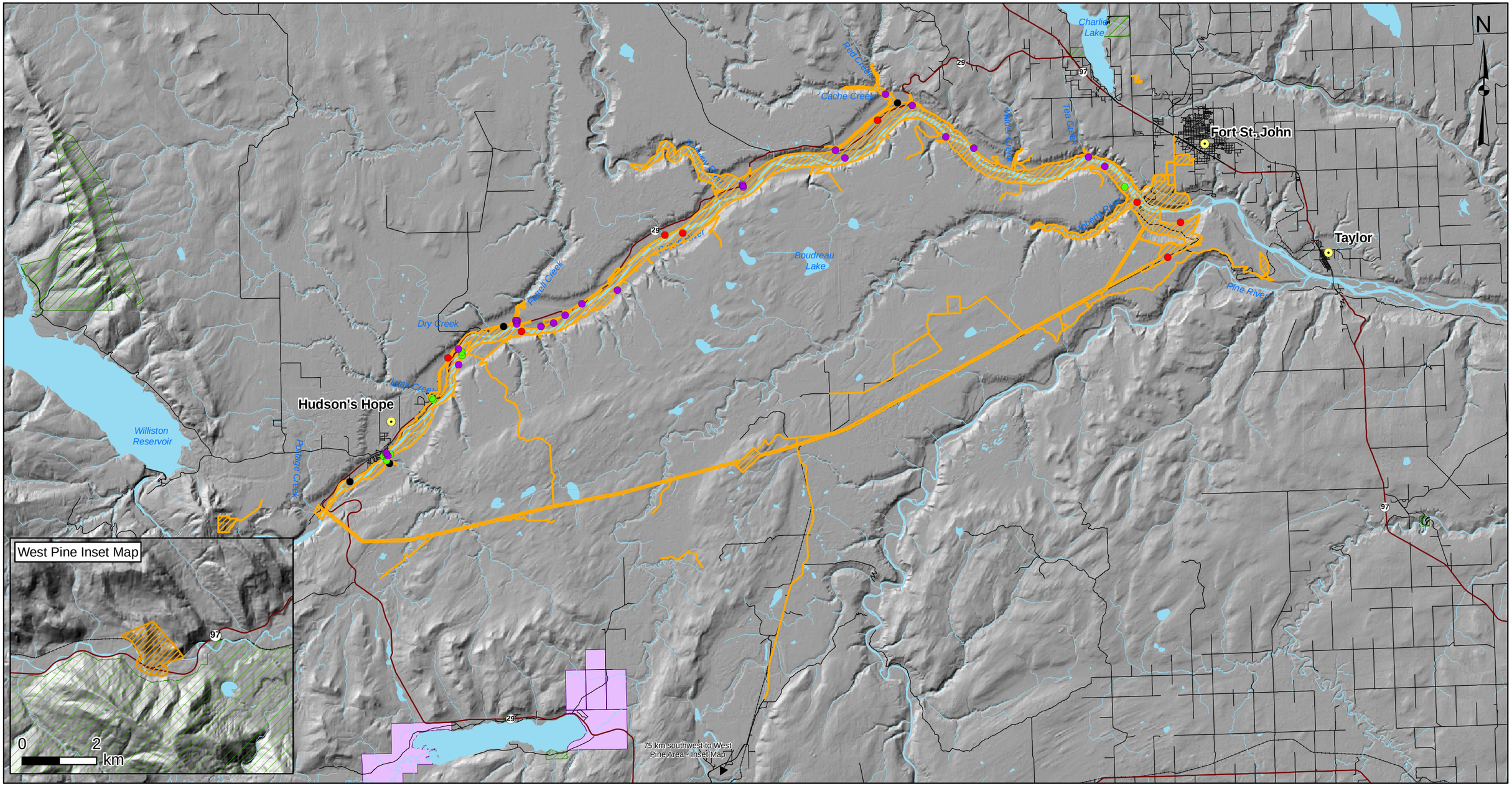
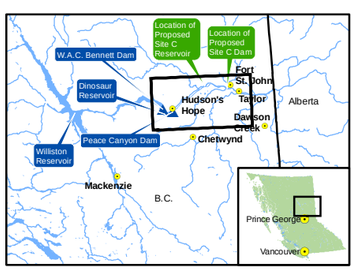
Figures 6.5 and 6.6 contain sensitive information that has been redacted from the public version of the Site C Clean Energy Project Environmental Impact Statement





Map Notes:
1. Datum/Projection: NAD83/UTM Zone 10N
2. Data Source: BC Hillshade model courtesy BC Environment, Lands and Parks. LiDAR hillshade acquired July/August 2006.

Legend

- Heritage Resources Local and Regional Assessment Area
- Protected Areas, Provincial Parks, Regional Parks and Ecological Reserves.
- Indian Reserve

Historical Site
- Class I
- Class II
- Class III
- Not Assessed

- City/District Municipality
- Existing Road
- Existing Highway
- Railway

1:300,000

0 12 km

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SITE C CLEAN ENERGY PROJECT

Figure 6.1
Historical sites

Date	Dec. 7, 2012	DWG NO	1016-C14-B4979-29	R 0

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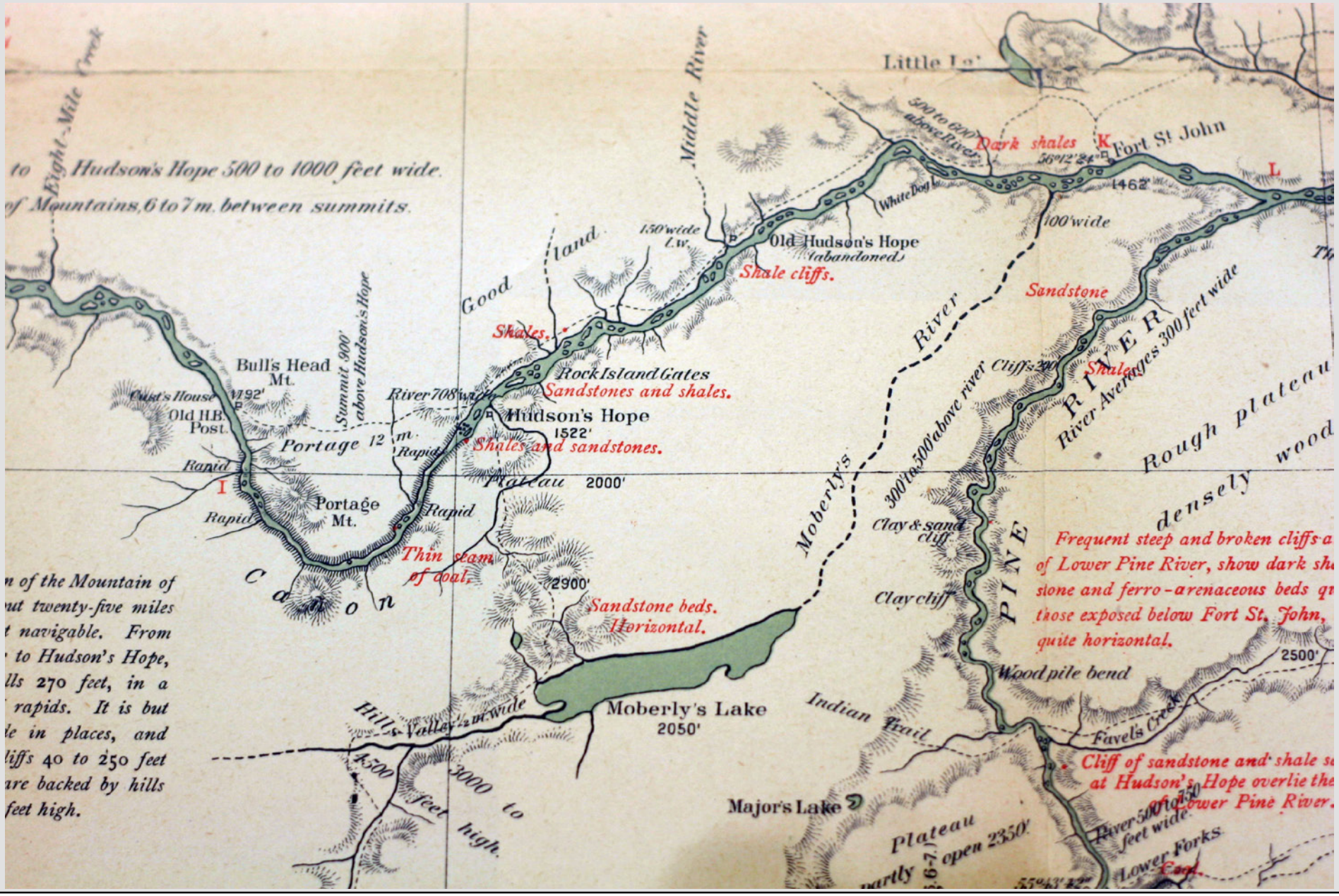

NOT TO SCALE

SITE C CLEAN ENERGY PROJECT

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Figure 6.2
1878 - 1880 Historical map

DATE	December 7, 2012		R 0

Map Notes:
1. Geological Survey of Canada 1879-1880

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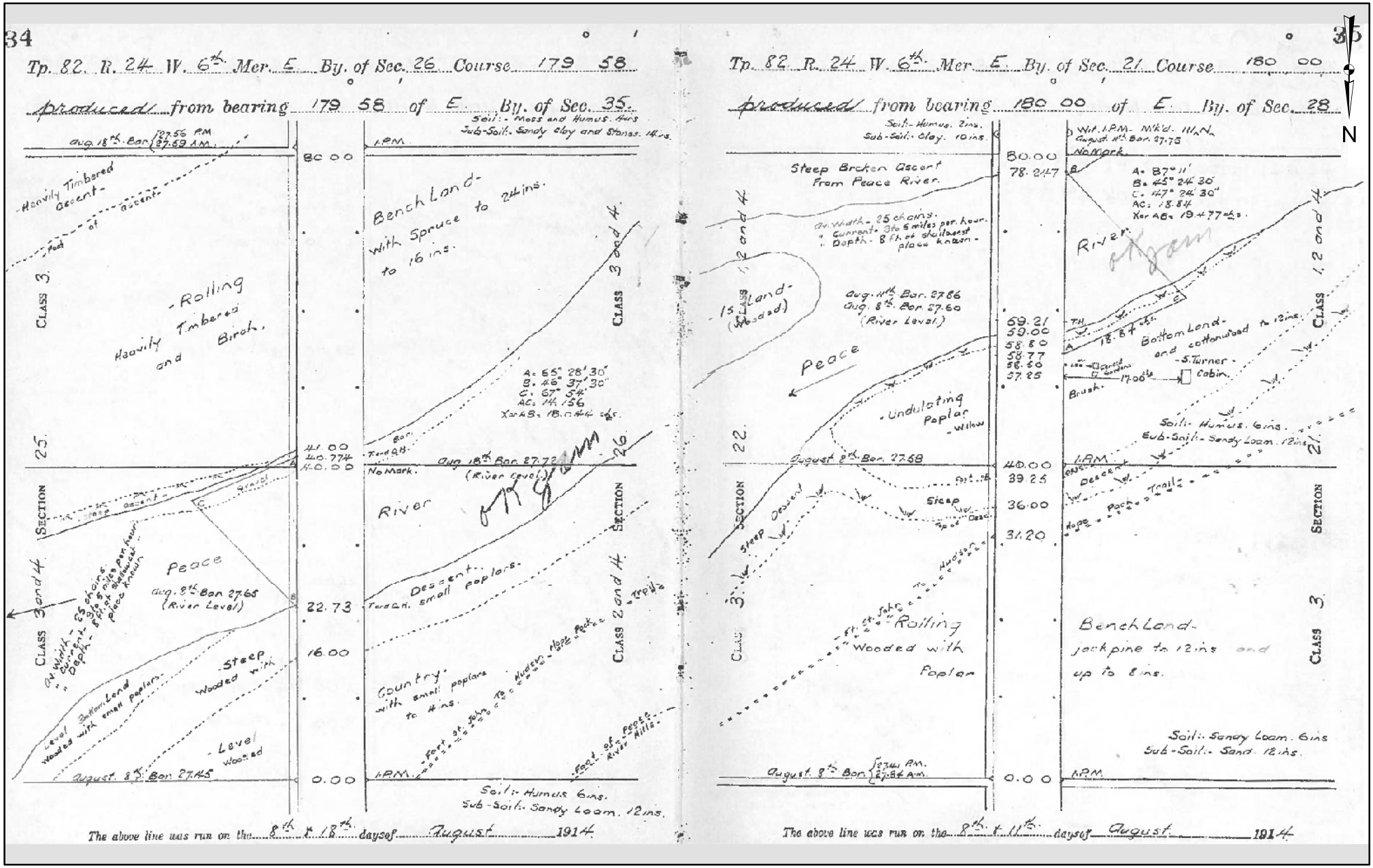

NOT TO SCALE

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Figure 6.3
Surveyor's field plan for portions of section 21, 22, 25 and 26, east of Farrell Creek, township 82, range 24, west of 6th meridian

DATE	December 7, 2012		R 0

Map Notes:
1. Brenot 1941a.

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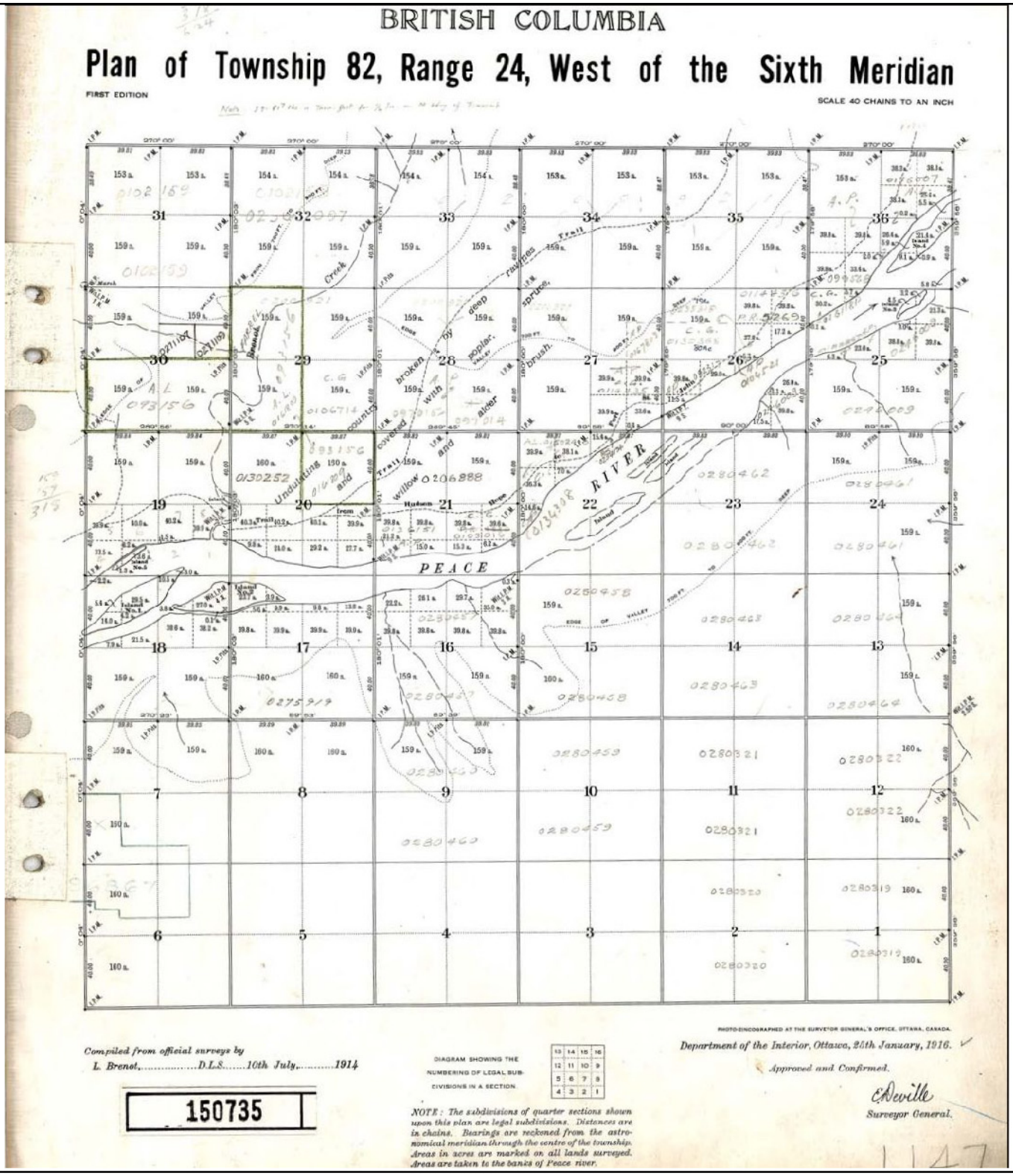

NOT TO SCALE

SITE C CLEAN ENERGY PROJECT	BC hydro / Golder Associates	
	Figure 6.4 Surveyed plan of township 82, range 24, west of 6th meridian	
DATE	December 7, 2012	R 0

Map Notes:
1. Department of the Interior 1916b.

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