BC Hydro
Power smart

Vegetation and Wildlife Mitigation and Monitoring Plan 2023 Annual Report Appendices 7-14

Site C Clean Energy Project

04 April 2024

Appendix 7. Ground Nesting Raptor Monitoring 2023 Annual Report

Site C Clean Energy Project
Ground-Nesting Raptor Monitoring
2023 Annual Report

PRESENTED TO

British Columbia Hydro and Power Authority

MARCH 11, 2024
ISSUED FOR USE
FILE: 704-ENW.PENW03042-02.GNRM23

Saulteau EBA Environmental Services Joint Venture.
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Site C Clean Energy Project Ground-Nesting Raptor Monitoring 2023 Annual Report

FILE: 704-ENW.PENW03042-02.GNRM23
September 27, 2023

PRESENTED TO

Site C Clean Energy Project
BC Hydro and Power Authority
P.O. Box 49260
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Prepared by:

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Senior Biologist

EXECUTIVE SUMMARY

Saulteau EBA Environmental Services Joint Venture (SEES JV) completed surveys of ground-nesting raptors (i.e., Short-eared Owl [*Asio flammeus*] and Northern Harrier [*Circus hudsonius*]) in the area of British Columbia Hydro and Power Authority's (BC Hydro) Site C Clean Energy Project ("Site C") in spring and summer 2023. The surveys were part of BC Hydro's Ground-Nesting Raptor Follow-up Monitoring Program. This report describes the methods used to conduct the surveys and provides a summary of the results.

The 2023 ground-nesting raptor surveys were conducted using two methods: (1) Field surveys were conducted along transects and at standwatch stations to detect Northern Harrier and Short-eared Owl, and (2) Autonomous Recording Units (ARUs) were established at select standwatch stations with the purpose of detecting Short-eared Owl through human-listening.

The ground-nesting raptor field surveys were completed within three cleared portions of the Site C construction headpond: Cache Creek, Bear Flats, and along the Peace River between the Halfway River and Moberly River. The surveys were conducted either through transects or through stationary standwatches. Ground-nesting raptor surveys were completed at each transect and standwatch station up to six times during May and June 2023 (three daytime surveys and three evening surveys at select sites). The cleared portions near Bear Flats and Cache Creek were accessed on foot and the areas along the Peace River were accessed by boat.

ARUs were deployed at seven stations throughout the survey area that were assessed as having the highest habitat potential for Short-eared Owl. These seven stations were located along transects or at standwatch stations in the Bear Flats and Peace River survey areas. The ARUs were retrieved after a month of recording and three audio recordings taken near sunset were randomly selected from separate nights at each station and analyzed and interpreted for Short-eared Owl through human listening.

No Northern Harriers or Short-eared Owls were detected during the field surveys, and no Short-eared Owls were detected through human listening of the ARU recordings.

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1.0 INTRODUCTION

Saulteau EBA Environmental Services Joint Venture (SEES JV) completed surveys of ground-nesting raptors in the area of British Columbia Hydro and Power Authority's (BC Hydro) Site C Clean Energy Project ("Site C") in spring and summer 2023. The surveys were part of BC Hydro's Ground-Nesting Raptor Follow-up Monitoring Program (BC Hydro 2016). Ground-nesting raptor surveys have occurred annually since 2016. This report describes the methods used to conduct the surveys and provides a summary of the results from 2023.

The Ground-Nesting Raptor Follow-up Monitoring Program is specifically focused on two ground-nesting raptor species: Short-eared Owl (*Asio flammeus)* and Northern Harrier (*Circus hudsonius)* (Table 1).

Table 1: Species Covered in the Ground-Nesting Raptor Follow-up Monitoring Program

Common Name	Scientific Name	BC List	COSEWIC [1] Status	SARA [2] Status
Short-eared Owl	*Asio flammeus*	Blue	Threatened	Schedule 1 – Special Concern
Northern Harrier	*Circus hudsonius*	Yellow	-	-

[1] COSEWIC – Committee on the Status of Endangered Wildlife in Canada.
[2] SARA – *Species at Risk Act*.

The objectives of the ground-nesting raptor monitoring program are to determine the following:

- The number of Northern Harrier and Short-eared Owl nesting in areas cleared within the construction headpond prior to reservoir filling;
- The effects of seasonal construction headpond flooding on Northern Harrier and Short-eared Owl nests; and
- The use of open fields within mitigation properties by Northern Harrier and Short-eared Owl as nesting habitat.

2.0 EXISTING DATA

Baseline surveys for Northern Harrier were conducted in 2010 in the Regional Assessment Area, which included the dam site and reservoir, the Peace River valley surrounding the reservoir, adjacent plateau areas north and south of the river, and the transmission line (Hilton et al. 2013). During the baseline surveys, one Northern Harrier was observed within the proposed reservoir footprint and 15 were observed outside the Peace River valley in plateau areas. An additional 50 Northern Harrier were recorded incidentally between 2006 and 2016. The majority of these observations were associated with agricultural fields and upland habitats outside of the Peace River valley. No nests of Northern Harrier were identified during the baseline studies. For the ground-nesting raptor follow-up monitoring conducted annually since 2016, Northern Harrier have been observed hunting within and adjacent to the proposed reservoir and one nest was found within the proposed reservoir footprint although not within an area cleared for reservoir filling.

Baseline surveys for Short-eared Owl were conducted in 2006, 2010, and 2012 in the Regional Assessment Area (Hilton et al., 2013). Short-eared Owls were not detected during surveys in 2006, although one was observed incidentally during another survey. Twelve Short-eared Owls were detected during surveys in 2010, with one detection indicating evidence of breeding (begging calls). No Short-eared Owls were observed in 2012. One of the 12 Short-eared Owl observations during the three years of baseline surveys was within the Peace River valley; all other observations were outside the valley in neighbouring plateau areas.

For the ground-nesting raptor follow-up monitoring conducted annually since 2016, no Short-eared Owls have been observed in or adjacent to cleared portions of the reservoir or elsewhere in the Peace River valley.

3.0 METHODS

The 2023 ground-nesting raptor surveys were conducted using two methods:

1. Following methodology adapted from the Resource Inventory Committee (RIC) *Inventory Methods for Raptors* (RIC 2001), field surveys were conducted along transects and at standwatch stations to detect Northern Harrier and Short-eared Owl; and
2. Autonomous Recording Units (ARUs) were deployed at select standwatch stations as a pilot study to determine if acoustic recordings could detect Short-eared Owl in late-evening hours when sites could not be surveyed by humans.

Surveys were conducted in cleared portions of the construction headpond between the dam site and the Halfway River. Surveys of the mitigation properties were conducted in 2016 and 2017. Ground-nesting raptor use of the mitigation properties has been well documented and further surveys would likely not provide new information. Surveys of the mitigation properties were therefore not conducted in 2023. Surveys of these areas will be conducted again when the reservoir has been inundated or when there are substantial land use changes or habitat modifications in the mitigation properties, whichever occur first.

3.1 Field Surveys

Surveys were conducted at 36 standwatch stations at the Bear Flats, Cache Creek, and Peace River sites (Table 2, Figures 1 to 8; Appendix B provides a full list of stations surveyed from 2016-2023). Among the three areas:

- Bear Flats had a single transect with five standwatch stations located along its length (Figure 2).
- Cache Creek consisted of a single standwatch station (Figure 3).
- Peace River was the largest survey area, with five transects (for a total of 25 standwatch stations) between the Moberly River and Cache Creek and five standwatch stations located between Cache Creek and the Halfway River (Figures 3 to 8). No new survey stations were established within the Peace River area in 2023.

Within these three areas, ground-nesting raptors were surveyed up to six times between May and June 2023 to capture early, middle, and later stages of their breeding season. Bear Flats and Cache Creek were accessed by foot and the cleared Peace River areas were accessed by boat. Surveys were completed by two teams of two observers. Each team was composed of a biologist with raptor survey experience and a field assistant (Appendix C).

Table 2: 2023 Survey Dates and Times

Survey Location	First Visit	Second Visit (Evening)	Third Visit	Fourth Visit (Evening)	Fifth Visit	Sixth Visit (Evening)
Bear Flats	May 11, 2023 07:57 – 10:51	May 11, 2023 19:30 – 20:28 (Only surveyed BFSW01 and BFSW02)	June 8, 2023 06:48 – 09:22	June 7, 2023 20:20 – 21:40 (Only surveyed BFSW01 and BFSW02)	June 26, 2023 08:41 – 11:13	June 25, 2023 19:45 – 20:42 (Only surveyed BFSW01 and BFSW02)
Cache Creek	May 11, 2023 11:57 – 12:17	May 11, 2023 20:43 – 21:03	June 8, 2023 07:15 – 07:35	June 7, 2023 19:43– 20:03	June 26, 2023 7:06 – 7:26	June 25, 2023 21:11 – 21:31
Peace River	May 9, 2023 07:27 – 14:51 & May 10, 2023 07:15 – 15:42	No evening surveys conducted	June 2, 2023 06:19 – 14:41 & June 4, 2023 09:54 – 10:18	No evening surveys conducted	June 20, 2023 06:08 – 14:28 & June 22, 2023 09:05– 09:51	No evening surveys conducted

Northern Harrier are diurnal, and research suggests they are generally active between 05:30 and 21:30 (Smith et al. 2011). Short-eared Owls are crepuscular so optimal survey timing is in the evening just prior to twilight (Wiggins at al. 2006). While most surveys were conducted during daytime hours, three evening surveys were conducted at three select sites to increase the likelihood of detecting any Short-eared Owl present (the “evening” visit columns in Table 2). The evening surveys were limited to areas that could be safely accessed by truck due to the logistical and safety considerations that come with conducting surveys in cleared portions of the reservoir that require boat access. Evening surveys would involve boating in very low light or dark conditions after surveys are complete, which would not be considered a safe work practice by BC Hydro.

General habitat information for each survey station was noted during surveys to determine the quality of the cleared area as hunting and nesting habitat for ground-nesting raptors. Notes were taken on vegetation species present and height of vegetation regrowth and photographs of the surrounding habitat were taken.

3.1.1 Transect Survey Protocol

The transect surveys were conducted by walking at a speed of 0.5 – 2 km/hr while looking and listening for birds. Surveyors stopped whenever required to confirm identification and record data. The walking transects were located only in cleared portions of the reservoir. Surveyors selected walking paths that provided visual coverage of the entire portion of suitable habitat in each area. During the transect, surveyors stopped at each established standwatch station to complete a standwatch survey. When located along transects, standwatch stations were spaced approximately 400 m to 600 m apart. From each standwatch station the surveyors had a view from the previous standwatch station to the next station in the transect. Adding these standwatches into the transect surveys allowed surveyors to observe areas for longer periods to increase the potential to observe bird activity and nesting behaviour for the purpose of locating ground-nesting raptor nests. Standwatches were conducted by observing from a stationary position for approximately 20 minutes.

Surveys were not completed during periods of high wind (greater than Beaufort 3; 12 – 19 km/hr), rain or fog, when bird activity and detectability were likely to be low. The order that the stations were visited was different on each of the survey days so that time of day varied between visits.

For all raptor observations, species, sex, age, activity, distance and compass direction were recorded. Other species were recorded as incidental observations (Appendix A). Since ground-nesting raptor nests can easily be destroyed by human traffic, surveyors were instructed to observe for behaviour suggesting a nest was nearby (e.g., one or both of the pair returning to the same location with nesting materials or food, a pair of Northern Harriers exchanging prey or nesting materials through aerial passes, or a male Short-eared Owl defending a nest with distraction displays) rather than conduct intensive foot searches to locate a nest.

3.1.2 Standwatch Survey Protocol Without Transects

Standwatch surveys in the absence of associated transects were conducted in cleared portions of the reservoir that (1) could not be visited by foot due to impassible terrain, and/or (2) could not be linked with other standwatch stations to form a transect. Standwatch stations were located in areas with good visibility of the cleared area. Standwatches were conducted by observing from a stationary position for approximately 20 minutes. Surveys were not completed during periods of high wind (greater than Beaufort 3, 12 – 19 km/hr), rain or fog. The order that the stations were visited were different on each of the survey days.

Ground-nesting raptor observations were collected following the same protocol as described in Section 3.1.1 for transect surveys.

3.2 Autonomous Recording Unit Surveys

An ARU is a standalone audio recording device that can be deployed and left for a period of time to record vocalizations or other sounds. The audio recordings are analyzed and interpreted once the recording units have been retrieved. ARUs are commonly used to survey birds (Shonfield and Bayne 2017). The benefit of using ARUs for bird surveys is that the units can be deployed during daylight hours in areas that cannot be easily or safely accessed after dark (i.e. along the Peace River) when species such as Short-eared Owl are active, allowing for monitoring in areas that would otherwise be difficult to survey.

Short-eared Owl are not especially vocal (Wiggins et al. 2020) and surveys for this species are best conducted using visual ground surveys. However, ARUs could be a useful supplement to visual surveys if Short-eared Owl vocalizations can be reliably detected in recordings. This would allow for listening of recordings at locations that could not otherwise be surveyed in evening hours.

To informally test the utility of ARUs for detecting Short-eared Owls at Site C, an experimental trial was conducted from 2020 to 2023. ARUs (Song Meter SM4 from Wildlife Acoustics Inc.) were deployed at select standwatch stations with the intent that Short-eared Owl would be detected by visual survey and recordings could then be reviewed to identify their vocalizations. Ideally, ARUs would be deployed at locations where Short-eared Owls were known to occur; however, previous surveys have not recorded any Short-eared Owl in or adjacent to the reservoir area.

ARUs were deployed at seven stations that were assessed as having the highest habitat potential for Short-eared Owl. These seven stations were located along transects or at standwatch stations in the Bear Flats and Peace River survey areas (Table 3). A description of the habitat at each ARU survey station can be found in Section 4.1.

Table 3. 2023 ARU Survey Station Locations

ARU Survey Station	Location Reference	UTM Zone	UTM Easting	UTM Northing
PRSW02	Along Peace River Transect #1	10V	623908	6233003
PRSW06	Along Peace River Transect #2	10V	626230	6232846
PRSW12	Along Peace River Transect #3	10V	620694	6232647
PRSW20	Along Peace River Transect #4	10V	617416	6232279
PRSW24	Along Peace River Transect #5	10V	613087	6235643
PRSW33	Peace River Standwatch Station	10V	606815	6234255
BFSW03	Along the Bear Flats transect	10V	612034	6237293

The ARUs were installed from May 9 to 11, 2023 and were collected from June 20 to 26, 2023. The ARUs were installed based on the deployment protocol of Lankau et al. (2015). Each unit was mounted on a wooden stake or affixed to a tree approximately 1 m from the ground. The ARUs were set to record for 10 minutes every half hour each evening for the duration of deployment. The evening recordings were collected between 20:00 to 00:10 (i.e., midnight). The ARUs recorded 2-channel stereo, compressed W4V-8 files at 24 KHz.

To increase the probability of Short-eared Owl detection, recordings that could be selected for human listening were restricted to those taken as close to sunset as possible (approximately 21:55 in June) as possible, when Short-eared Owls are likely to be most active. Three 10-minute recordings, taken at either 21:30 or 22:00, were randomly selected from each station for auditory screening, for a total of 21 recordings. The three recordings were selected from different nights during the ARU deployment period. If a selected recording had persistent wind or rain, a new recording was randomly selected to avoid periods of low Short-eared Owl activity or decreased ability to detect sounds. The compressed W4V files were converted to uncompressed WAV files using the Kaleidoscope software (version 5.3.8) by Wildlife Acoustics. The uncompressed WAV files were then opened in Audacity (version 2.4.2) and screened for Short-eared Owl calls, including barks, screams, bill snaps and male courtship hoots at 1-minute intervals. The observer would replay any section needed to accurately track and count Short-eared Owl detections, and estimate perceived distance to each individual (near, mid and far). Auditory screening was conducted by the same observer for all recordings.

4.0 RESULTS

4.1 Habitat at Survey Areas

A description of the habitat at each survey station is provided in Table 4. Photographs of the habitat at each station are presented on Figures 2 to 8.

Table 4: Habitat at Peace River Standwatch Stations and Transects during the 2023 Surveys

Transect or Survey Station	Cleared	Growing Seasons Since Clearing	Habitat
Bear Flats Survey Area – Transect Only			
Bear Flats Transect ▪ BFSW01 ▪ BFSW02 ▪ BFSW03 ▪ BFSW04 ▪ BFSW05	Winter 2018/2019	4	The cleared area was experiencing vegetation regrowth with high percent cover (> 90%) of grasses, forbs and shrubs. Shrubs and pole saplings were approximately 1-2 m high and dominant species included trembling aspen and saskatoon. The cleared area is bounded by the Peace River to the south and by aspen forests growing on dry south-facing slopes to the north.
Cache Creek Survey Area – Standwatch Only			
CCSW07	Partial clearing in Winter 2016/2017 Partial clearing in Winter 2018/2019	6 4	Reestablished vegetation is dominated by grasses and patches of low shrubs approximately 1-2 m in height. The area is oriented south towards Cache Creek, bounded by Highway 29 to the north and surrounded by deciduous riparian forests.
Peace River Survey Area – Transect and Standwatch			
Peace River Transect #1 ▪ PRSW02 ▪ PRSW03 ▪ PRSW04	Winter 2017/2018	5 Brushed in winter 2022	A cleared river valley bench with herbaceous and shrubby regrowth covering 90% of the cleared area. The cleared area was recently brushed, and all the shrubs were below 30 cm in height. The dominant shrubs are prickly rose, saskatoon and wolf willow. It is bounded on the northern and southern sides by intact strips of open riparian forest between the cleared area and the Peace River.
Peace River Transect #2 ▪ PRSW05 ▪ PRSW06 ▪ PRSW07 ▪ PRSW08	Winter 2017/2018	5 Brushed in winter 2022	A cleared stretch of coniferous forest on a north-facing slope with abundant grass, herb and shrub regrowth covering 90% of the area. The cleared area was recently brushed, and all the shrubs were below 30 cm in height. The transect is bounded to the south by the Peace River, and to the north and west by coniferous forest.
Peace River Transect #3 ▪ PRSW11 ▪ PRSW12 ▪ PRSW13 ▪ PRSW14 ▪ PRSW15	Winter 2018/2019 (Except PRSW15 which was cleared 2019 / 2020)	4 3 Partially brushed in winter 2022	A large, cleared area encompassing Tea Island. The old back channels that braid through this area are dominated by forbs and grasses, and the upland areas are revegetating with forbs, grasses and shrubs. Vegetation cover along the transect was high (>90%). Four of the stations were recently brushed, and all the shrubs were below 30 cm in height. PRSW15 remains unbrushed, and most of the shrubs are around 1.0 m tall, with some 2.0 m tall balsam poplar saplings. The transect is bounded by dry south-facing slopes to the north and an intact strip of riparian forest along the Peace River to the south.
Peace River Transect #4 ▪ PRSW16 ▪ PRSW17 ▪ PRSW18 ▪ PRSW19 ▪ PRSW20	Winter 2019/2020	3 Brushed in winter 2022	The flat floodplain areas and the southern slopes were cleared and mulched, with grass, herb and shrub regrowth covering 80% of the area. The cleared area was recently brushed, and all the shrubs were below 30 cm in height. It is bounded to the north by the Peace River, and to the south by coniferous forest. Riparian buffers were left around the perimeters of the clearcut areas.

Transect or Survey Station	Cleared	Growing Seasons Since Clearing	Habitat
▪ PRSW21 ▪ PRSW22 ▪ PRSW23			
Peace River Transect #5 ▪ PRSW24 ▪ PRSW25 ▪ PRSW26 ▪ PRSW27 ▪ PRSW28	Winter 2019/2020	3 Partially brushed in winter 2022	This area had been cleared and mulched. Some exposed soils, and abundant small and large woody debris still remain. Vegetation regrowth was moderate and consisted of grasses, herbs and shrubs covering approximately 80% of the area. Dominant shrub species are prickly rose and soopolallie. The majority of the transect was recently brushed and shrubs within these areas were below 30 cm. Vegetation was not brushed at PRSW26, or south of PRSW27. In these areas, shrubs were approximately 1.0 m high. The transect is bounded to the north by the Peace River, and to the south by coniferous forest. Riparian buffers were left around the perimeters of the clearcut areas.
PRSW31	Winter 2019/2020	3	The area had been cleared and mulched. Approximately 90% of the area was experiencing vegetation regrowth, and consisted of grasses, herbs and low shrubs around 1.0 m in height. The station is located on a river island and a riparian buffer was left around the perimeter of the cleared island.
PRSW32	Winter 2019/2020	3	The area had been cleared and mulched. Approximately 85% of the area was experiencing vegetation regrowth, and consisted of grasses, herbs and low shrubs around 1.0 m in height. Some balsam poplar saplings are 2.0 m tall. The station is located on a river island and a riparian buffer was left around the perimeter of the cleared island.
PRSW33	Winter 2019/2020	3	The area had been cleared and mulched. Approximately 85% of the area was experiencing vegetation regrowth and consisted of grasses, herbs and low shrubs under 1.0 m in height. The station is located on a river island and a riparian buffer was left around the perimeter of the cleared island.
PRSW34	Winter 2019/2020	3 Brushed in winter 2022	A small, cleared area surrounded by mainly deciduous trees. Approximately 90% of the cleared and grubbed area was experiencing vegetation regrowth and consisted mostly of grasses, herbs and low shrubs. The cleared area was recently brushed, and all the shrubs were below 30 cm in height. It is bounded to the east and south by the Peace River and to the north by floodplains, and Highway 29.
PRSW35	Winter 2019/2020	3 Brushed in winter 2022	A small, cleared area surrounded by mainly deciduous trees. Approximately 90% of the cleared and grubbed area was experiencing vegetation regrowth and consisted mostly of grasses, herbs and low shrubs. The cleared area was recently brushed, and all the shrubs were below 30 cm in height. It is bounded to the east and south by the Peace River and to the north by floodplains, and Highway 29.

4.2 Transect Results

There were no Northern Harrier or Short-eared Owl observed during the transect surveys.

4.3 Standwatch Results

There were no Northern Harrier or Short-eared Owl observed during the standwatch surveys.

4.4 Incidental Observations

On June 22, 2023 at 9:12 a.m., one male Northern Harrier was incidentally observed hunting in a backchannel floodplain area south of PRSW31. The approximate UTM coordinates of the incidental observations were 10V 600130 E, 6232914 N. There were no incidental observations of Short-eared Owl in 2023.

4.5 ARU Survey Results

Three 10-minute recordings from each of the seven stations were auditory screened and analyzed, for a total of 21 recordings. No Short-eared Owls were detected.

5.0 DISCUSSION

The first clearing of the headpond area occurred in fall/winter 2016/2017 and continued incrementally each year through to winter 2020. Prior to the third growing season, vegetation regrowth in cleared areas remained moderate (less than 75% coverage, and shrubs below 0.5 m in height) and suitable ground-nesting raptor breeding habitat in cleared areas appeared to be absent or of very low quality. Cleared areas in their third growing season and beyond had high coverage of grasses, forbs and taller shrubs and appeared to provide suitable breeding habitat for ground-nesting raptors. Over the winter of 2022, the vegetation in many of the clearings was brushed to a height of 30 cm or shorter in preparation for reservoir flooding. The brushed areas provided less cover for nesting raptors and may have reduced the amount of suitable breeding habitat for ground-nesting raptors in the headpond area.

The 2023 ground-nesting raptor surveys did not detect Northern Harrier in or adjacent to the Project footprint. One Northern Harrier was incidentally observed in Project footprint south of PRSW31 on June 22, 2023; however, this observation occurred during another field program.

Short-eared Owls were not detected during the 2023 ground-nesting raptor surveys, which is consistent with the previous years' findings. Short-eared Owls have not been observed in or adjacent to the Project footprint since surveys began in 2016. The experimental use of ARUs to detect Short-eared Owl using audio recordings continues to be inconclusive since no Short-eared Owl were detected in 2020, 2021, 2022, or 2023.

6.0 REFERENCES

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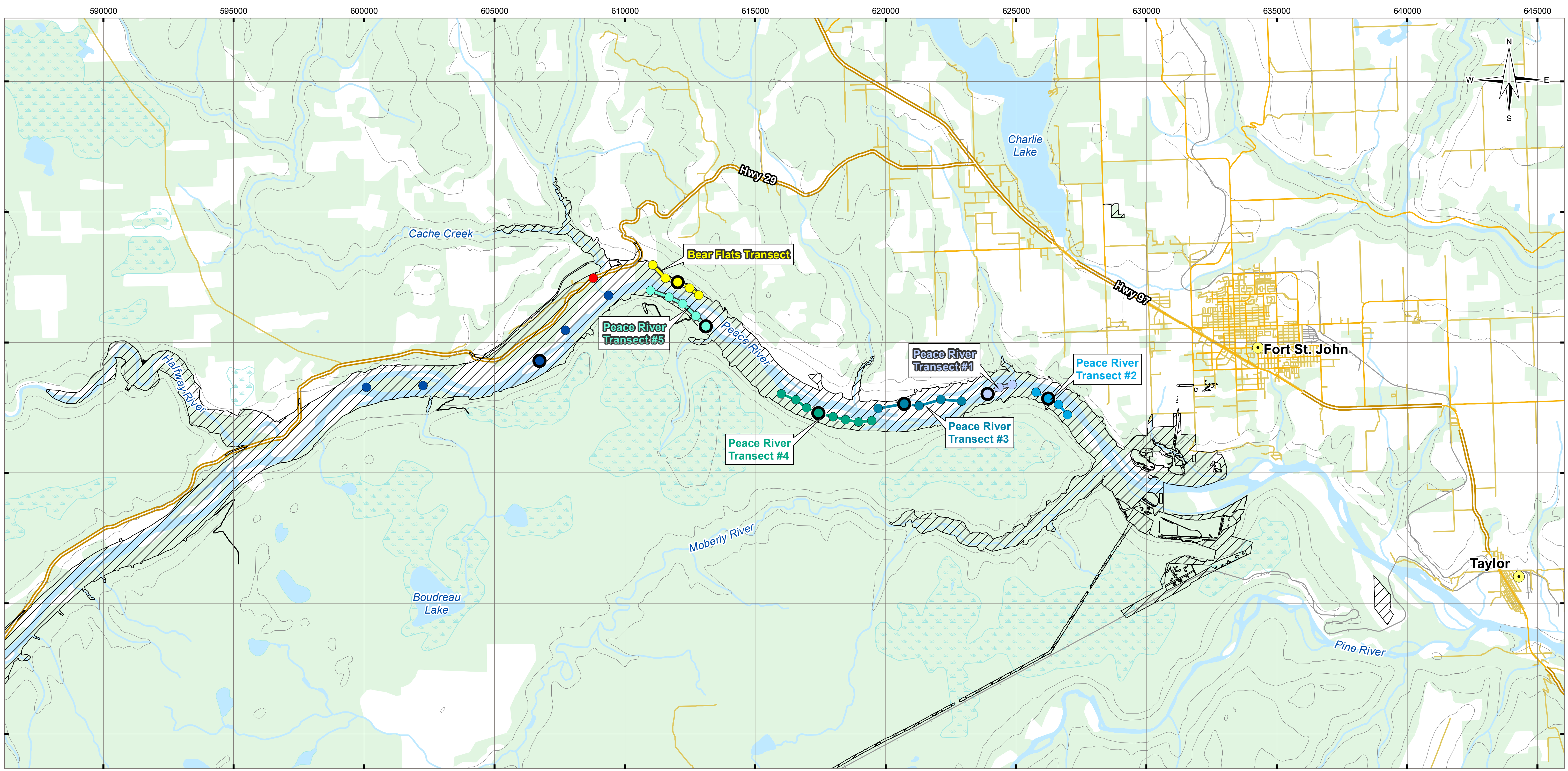
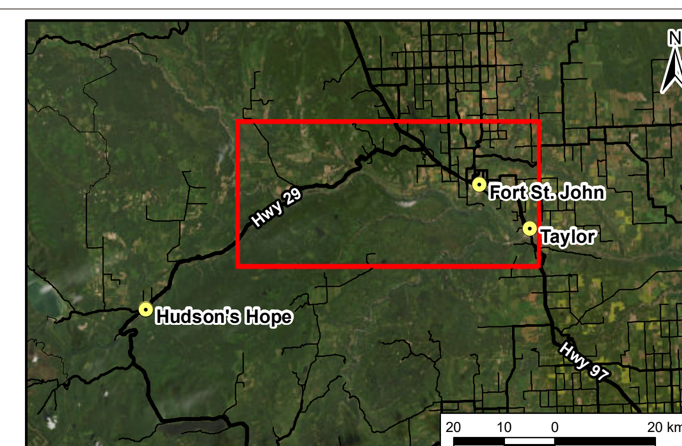
FIGURES





LEGEND

Project Footprint
ARU Station

Standwatch Station
- Cache Creek
- Peace River

Transect Standwatch Station
- Bear Flats
- Peace River #1
- Peace River #2
- Peace River #3
- Peace River #4
- Peace River #5

Transect
- Bear Flats
- Peace River #1
- Peace River #2
- Peace River #3
- Peace River #4
- Peace River #5

- Populated Place
- Highway
- Main Road
- Local Road
- Resource/Recreational Road
- Railway
- Residential Area

- Contour (100 m)
- Watercourse
- Waterbody
- Wetland
- Wooded Area

NOTES
Base data source: CanVec 1:250,000 (2019).

STATUS
ISSUED FOR REVIEW

SITE C GROUND-NESTING RAPTOR MONITORING 2023 ANNUAL REPORT

Project Overview

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC Hydro Power smart

Scale: 1:150,000
2 1 0 2
Kilometres

FILE NO.
PENW03042-02_Fig01_Overview.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	EH	0

DATE	PROJECT NO.
March 2024	ENW.PENW03042-02

Figure 1

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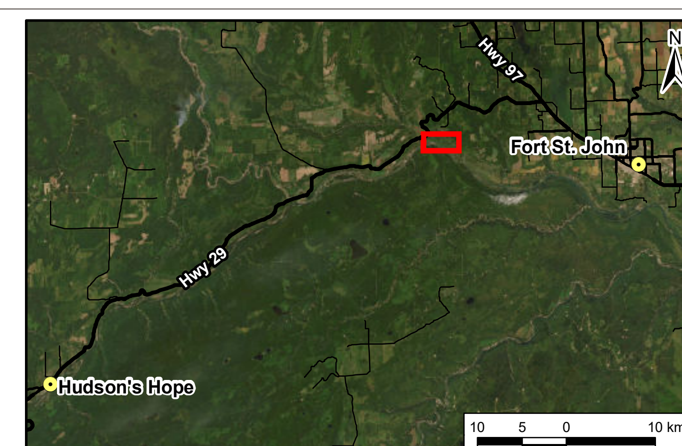
LEGEND

- ARU Station
- Bear Flats Transect Standwatch Station
- Bear Flats Transect
- Project Footprint
- Highway
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2021).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2023 ANNUAL REPORT

Bear Flats Transect Stations

PROJECTION	DATUM
UTM Zone 10	NAD83

Scale: 1:10,000
200 100 0 200
Metres

CLIENT
BC Hydro Power smart
TETRA TECH

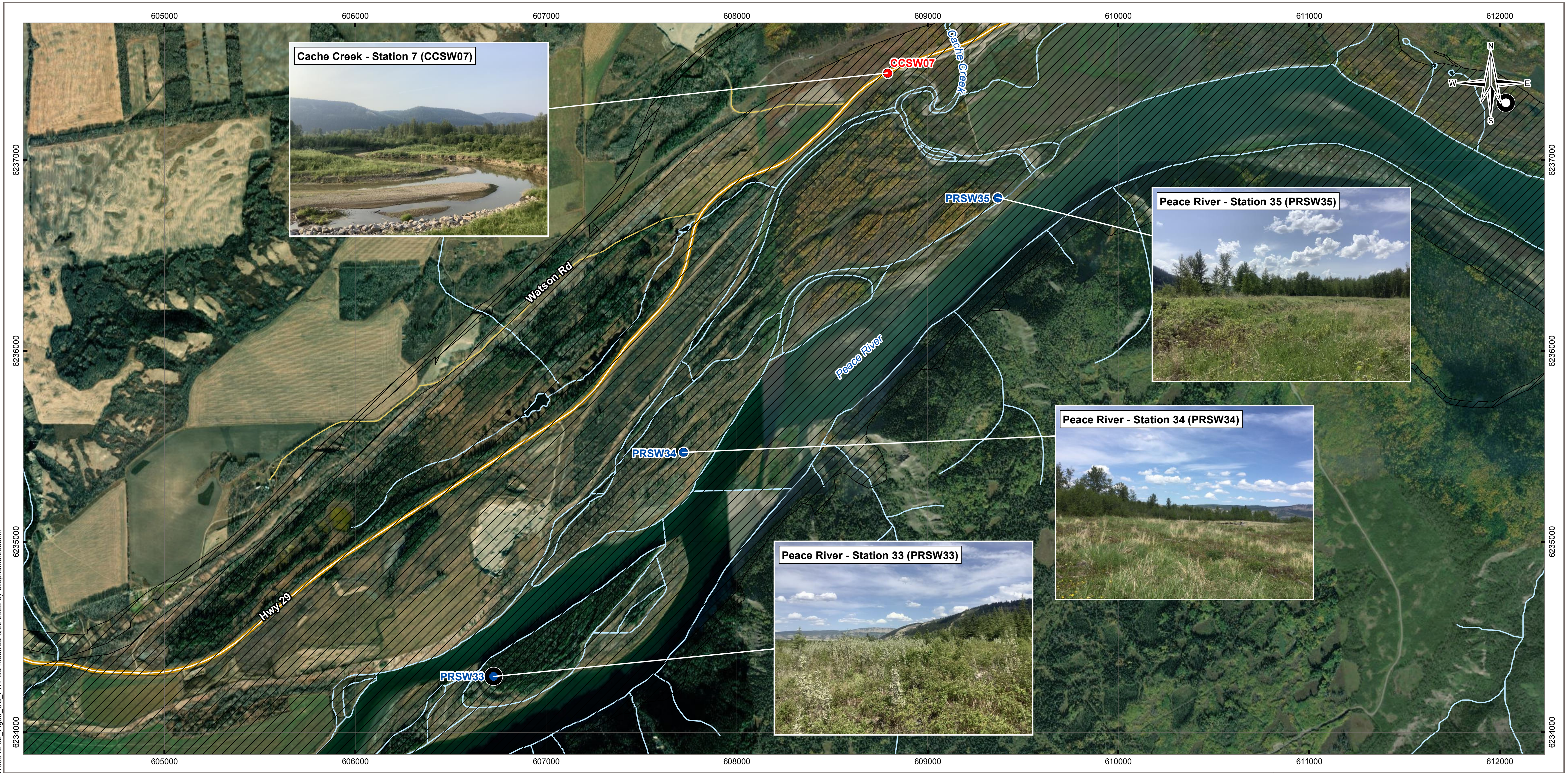
FILE NO.
PENW03042-02_Fig02_BearFlats.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	EH	0

DATE	PROJECT NO.
March 2024	ENW.PENW03042-02

Figure 2

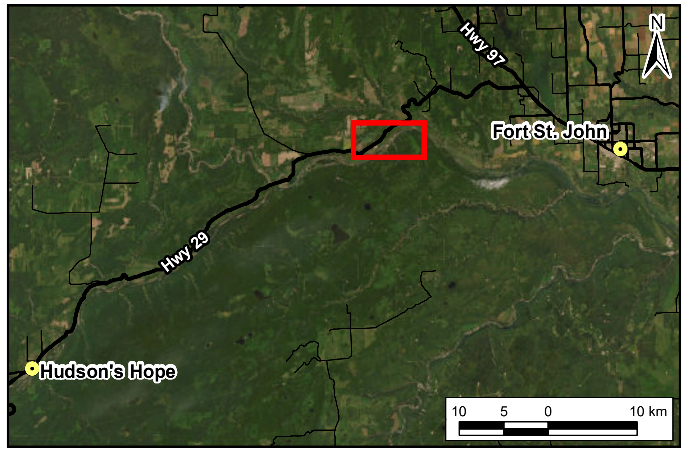
G:\ENVIRONMENTAL\PENW\PENW03042-02\Maps\GNRM_2023\PENW03042-02_Fig02_BearFlats.mxd modified 8/22/2023 by Stephanie.Leusink



G:\ENVIRONMENTAL\PENW\PENW03042-02\Maps\GNRM_2023\PENW03042-02_Fig03_CC_PR.mxd modified 8/22/2023 by Stephanie.Leusink

LEGEND

- ARU Station
- Cache Creek Standwatch Station
- Peace River Standwatch Station
- Project Footprint
- Highway
- Local Road
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2018-2021).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2023 ANNUAL REPORT

Cache Creek and Peace River Standwatch Stations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC Hydro Power smart

Scale: 1:20,000
400 200 0 400
Metres

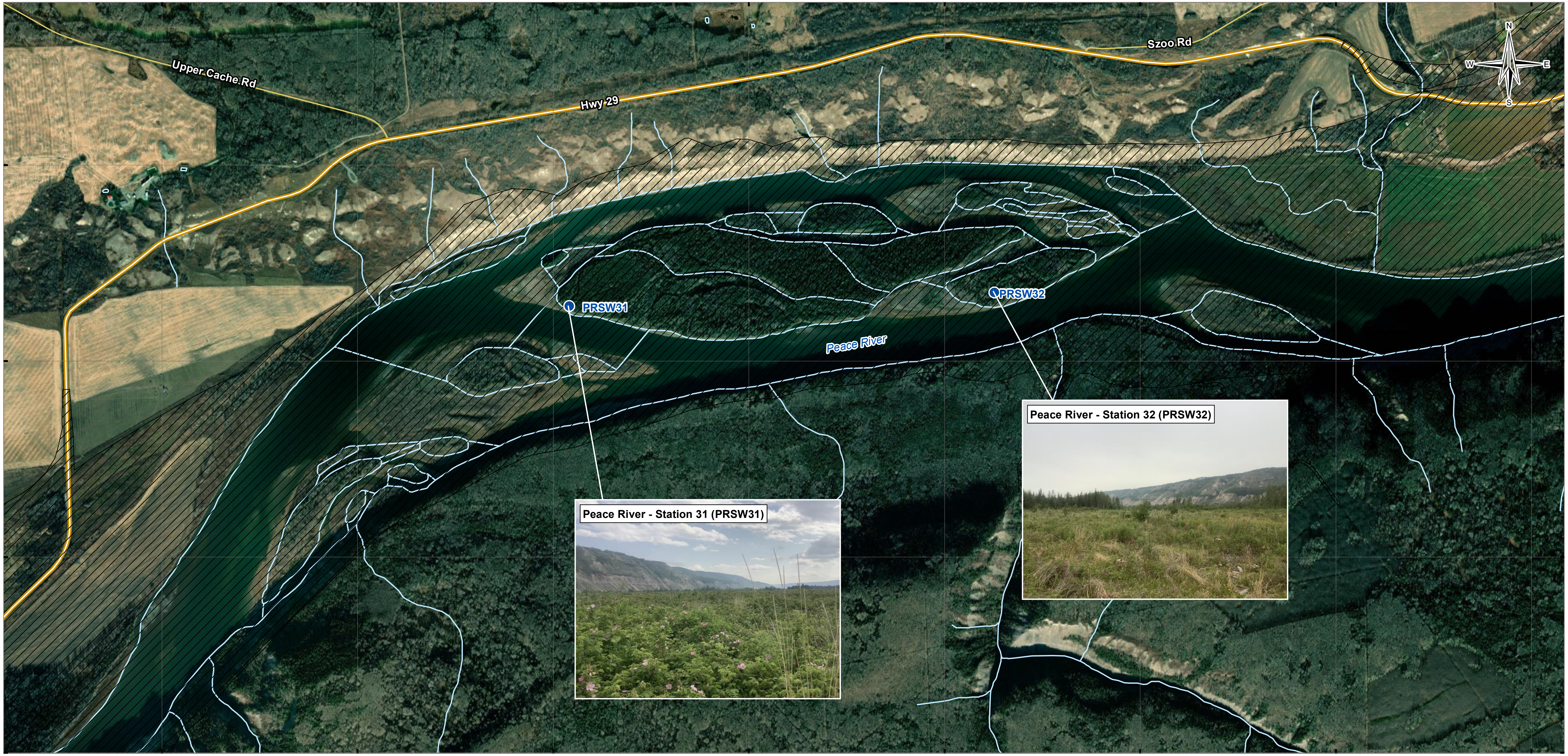
FILE NO.
PENW03042-02_Fig03_CC_PR.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	EH	0

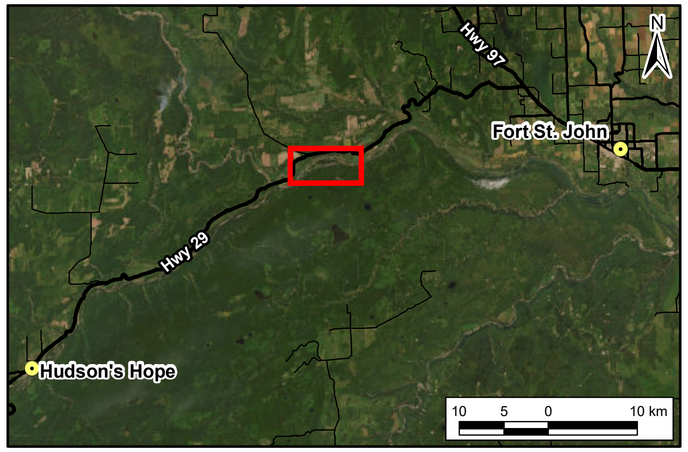
DATE	PROJECT NO.
March 2024	ENW.PENW03042-02

Figure 3



LEGEND

- Peace River Standwatch Station
- Project Footprint
- Highway
- Local Road
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2018).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2023 ANNUAL REPORT

Peace River Standwatch Stations

PROJECTION	DATUM
UTM Zone 10	NAD83

Scale: 1:20,000

400 200 0 400

Metres

FILE NO.
PENW03042-02_Fig04_PeaceR.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	EH	0

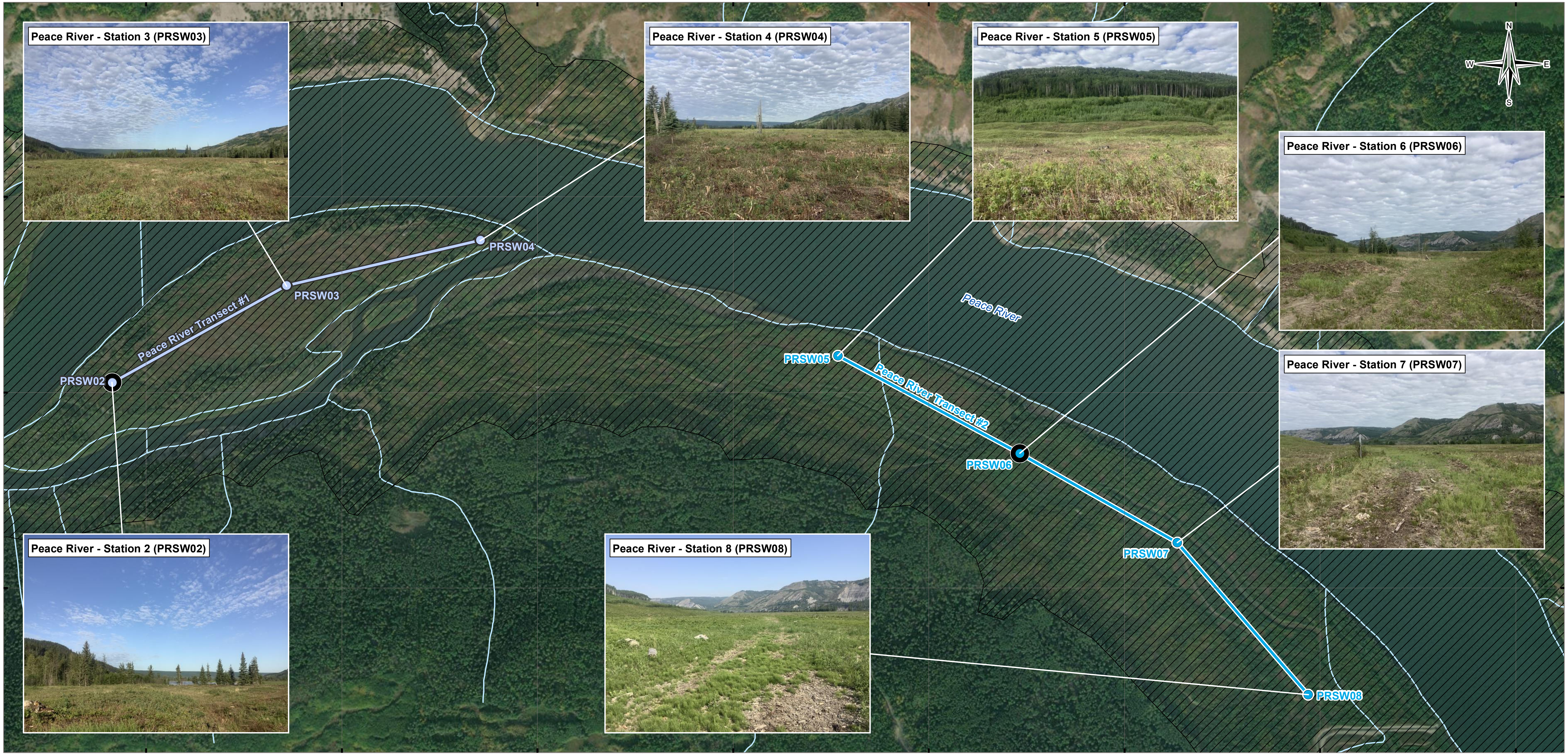
DATE	PROJECT NO.
March 2024	ENW.PENW03042-02

CLIENT
BC Hydro Power smart

TETRA TECH

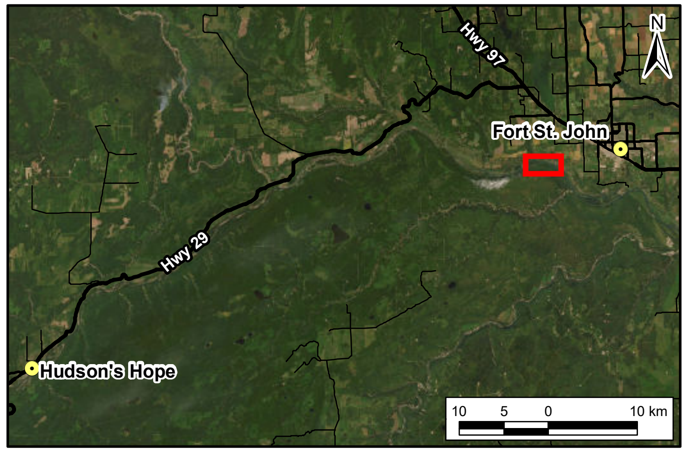
Figure 4

G:\ENVIRONMENTAL\PENW\PENW03042-02\Maps\GNRM_2023\PENW03042-02_Fig04_PeaceR.mxd modified 8/22/2023 by Stephanie.Leusink



LEGEND

- ARU Station
- Peace River Transect #1 Standwatch Station
- Peace River Transect #2 Standwatch Station
- Peace River Transect #1
- Peace River Transect #2
- Project Footprint
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2022).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2023 ANNUAL REPORT

Peace River Transect #1 and Transect #2 Standwatch Stations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC Hydro Power smart

Scale: 1:10,000
200 100 0 200
Metres

FILE NO.				
PENW03042-02_Fig05_PeaceR_T1T2.mxd				
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	EH	0
DATE	PROJECT NO.			
March 2024	ENW.PENW03042-02			

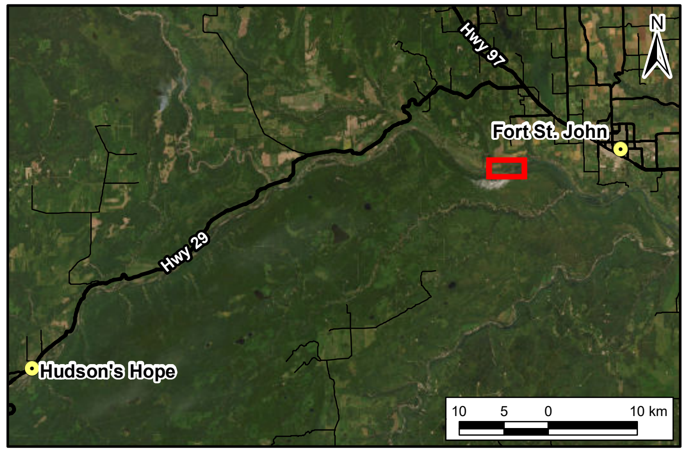
TETRA TECH

Figure 5

G:\ENVIRONMENTAL\PENW\PENW03042-02\Maps\GNRM_2023\PENW03042-02_Fig06_PeaceR_T3.mxd modified 8/22/2023 by Stephanie Leusink

LEGEND

- ARU Station
- Peace River Transect #3 Standwatch Station
- Peace River Transect #3
- Project Footprint
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2021/2022).

STATUS
ISSUED FOR USE

SITE C
GROUND-NESTING RAPTOR MONITORING
2023 ANNUAL REPORT

Peace River Transect #3
Standwatch Stations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC Hydro Power smart

Scale: 1:10,000
200 100 0 200
Metres

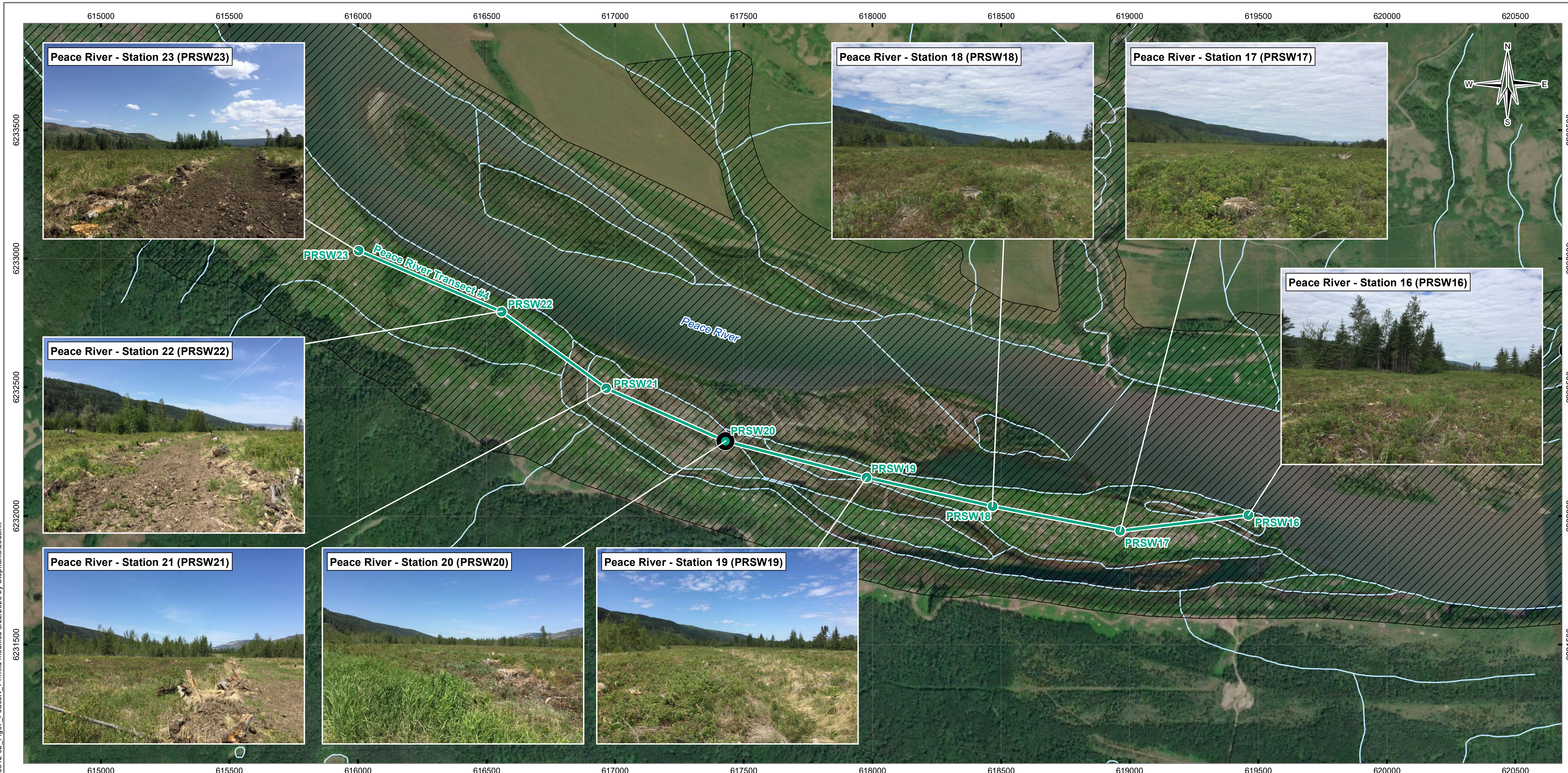
FILE NO.
PENW03042-02_Fig06_PeaceR_T3.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	EH	0

DATE	PROJECT NO.
March 2024	ENW.PENW03042-02

Figure 6



LEGEND

- ARU Station
- Peace River Transect #4 Standwatch Station
- Peace River Transect #4
- Project Footprint
- Watercourse
- Waterbody

NOTES
Base data source:
CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2021).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2023 ANNUAL REPORT

Peace River Transect #4 Standwatch Stations

PROJECTION	DATUM
UTM Zone 10	NAD83

Scale: 1:15,000
200 100 0 200
Metres

CLIENT
BC Hydro Power smart
TETRA TECH

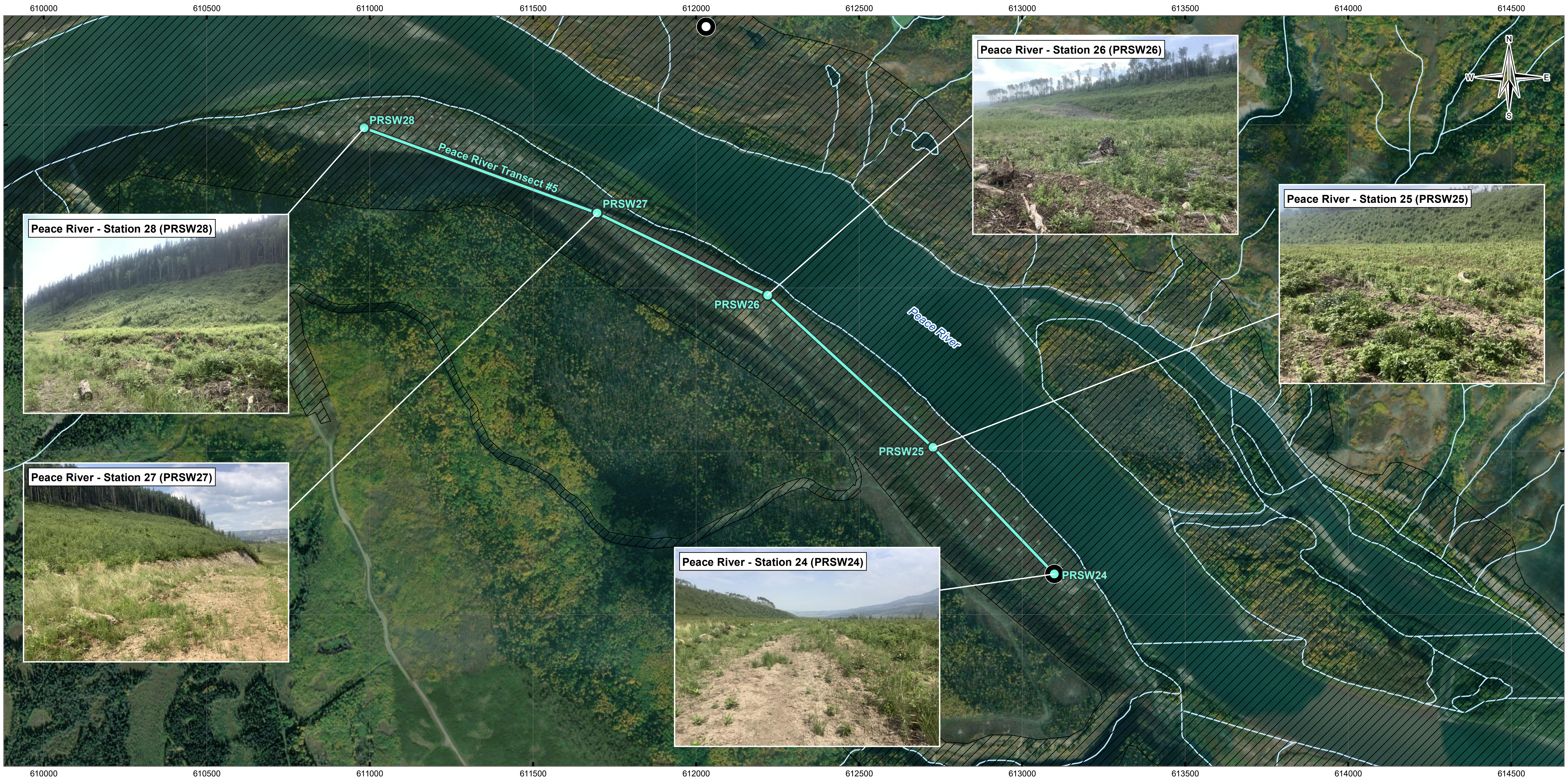
FILE NO.
PENW03042-02_Fig07_PeaceR_T4.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	EH	0

DATE	PROJECT NO.
March 2024	ENW.PENW03042-02

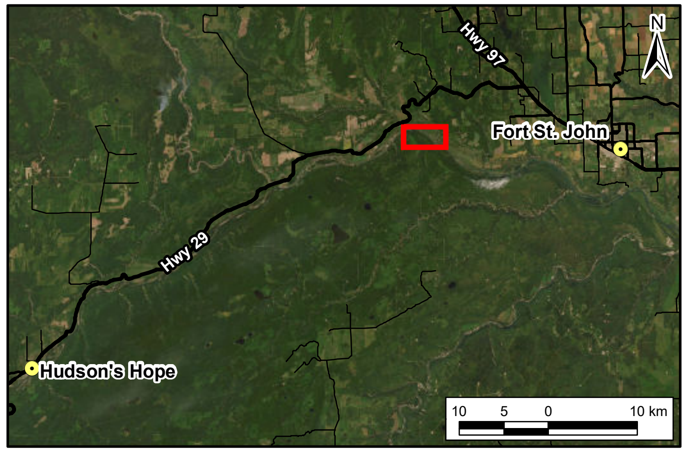
Figure 7

G:\ENVIRONMENTAL\PENW\PENW03042-02\Maps\GNRM_2023\PENW03042-02_Fig07_PeaceR_T4.mxd modified 8/22/2023 by Stephanie.Leusink



LEGEND

- ARU Station
- Peace River Transect #5 Standwatch Station
- Peace River Transect #5
- Project Footprint
- Watercourse
- Waterbody



NOTES
Base data source:
CanVec 1:50,000 (2019).
Imagery from ESRI; Maxar (2021).

STATUS
ISSUED FOR USE

SITE C GROUND-NESTING RAPTOR MONITORING 2023 ANNUAL REPORT

Peace River Transect #5 Standwatch Stations

PROJECTION	DATUM	CLIENT
UTM Zone 10	NAD83	BC Hydro Power smart

Scale: 1:12,000
200 100 0 200
Metres

FILE NO.
PENW03042-02_Fig08_PeaceR_T5.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	SL	BB	EH	0

DATE	PROJECT NO.
March 2024	ENW.PENW03042-02

TETRA TECH

Figure 8

G:\ENVIRONMENTAL\PENW\PENW03042-02\Maps\GNRM_2023\PENW03042-02_Fig08_PeaceR_T5.mxd modified 8/22/2023 by Stephanie.Leusink

APPENDIX A
INCIDENTAL RAPTOR OBSERVATIONS

Table A.1: Incidental Observation of Other Raptors During Ground-Nesting Raptor Surveys

Common Name	Scientific Name	BC List	COSEWIC/SARA [1]	Number Observed		
				Bear Flats	Cache Creek	Peace River
Golden Eagle	*Aquila chrysaetos*	Yellow	Not at Risk (May 1984)	1	-	-
Red-tailed Hawk	*Buteo jamaicensis*	Yellow	Not at Risk (May 1995)	-	-	2
Merlin	*Falco columbarius*	Yellow	Not at Risk (April 1985)	1	-	4
American Kestrel	*Falco sparverius*	Yellow	-	8	-	1
Bald Eagle	*Haliaeetus leucocephalus*	Yellow	Not at Risk (May 1984)	3	2	15
Osprey	*Pandion haliaetus*	Yellow	-	-	1	-

APPENDIX B
SURVEY STATION HISTORY 2016 – 2023

Survey Area	Station	Accompanying Transect	UTM Coordinates			Survey Year							
			Zone	Easting	Northing	2016	2017	2018	2019	2020	2021	2022	2023
Compensation Sites	Wilder Creek Lands	No	-	-	-	Surveyed	Surveyed	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *
	Ruttledge Property	No	-	-	-	Surveyed	Surveyed	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *
	Marl Fen Property	No	-	-	-	Surveyed	Surveyed	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *	Not surveyed *
Highway 29	H29SW01	No	10	604838	6234918		Surveyed	Surveyed	Surveyed	Active Haul Road	Active Haul Road	Active Haul Road	Active Haul Road
	H29SW02	No	10	607633	6236693		Surveyed	Surveyed	Surveyed	Surveyed	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.
	H29SW03	No	10	609150	6237937		Surveyed	Surveyed	Renamed CCSW05 and included in the CC Transect.	Renamed CCSW05 and included in the CC Transect.	Renamed CCSW05 and included in the CC Transect.	Renamed CCSW05 and included in the CC Transect.	Renamed CCSW05 and included in the CC Transect.
	H29SW04	No	10	606078	6234708			Surveyed	Active Construction (Gravel Pit)	Active Construction (Gravel Pit)	Active Construction (Gravel Pit)	Active Construction (Gravel Pit)	Active Construction (Gravel Pit)
	H29SW05	No	10	606918	6235242			Surveyed	Surveyed	Disturbed by construction - soil piles, grading etc. Established H29SW06 nearby as replacement.	Disturbed by construction - soil piles, grading etc. Established H29SW06 nearby as replacement.	Disturbed by construction - soil piles, grading etc. Established H29SW06 nearby as replacement.	Disturbed by construction - soil piles, grading etc. Established H29SW06 nearby as replacement.
	H29SW06	No	10	607050	6235314					Established to replace H29SW05	Surveyed	Not surveyed due to access issues - active construction area.	Not surveyed due to access issues - active construction area.
Peace River	PRSW01	No	10	623128	6232853		Surveyed	Surveyed	Surveyed	Redundant	Redundant	Redundant	Redundant
	PRSW02	Peace River Transect 1	10	623914	6233025		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW03		10	624359	6233273		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW04		10	624854	6233389		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW05	Peace River Transect 2	10	625768	6233094		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW06		10	626233	6232844		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW07		10	626635	6232616		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW08		10	626969	6232228		Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW09		10	627381	6231920		Surveyed	Surveyed	Active Construction	Active Construction	Active Construction	Active Construction	Active Construction
	PRSW10	No	10	617729	6232813				Surveyed	Redundant	Redundant	Redundant	Redundant
	PRSW11	Peace River Transect 3	10	619709	6232467				Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW12		10	620706	6232643				Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW13		10	621282	6232572				Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW14		10	622910	6232747				Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	PRSW15		10	622118	6232805					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW16	Peace River Transect 4	10	619462	6232003					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW17		10	618963	6231942					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW18		10	618468	6232038					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW19		10	617978	623215					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW20		10	617429	6232291					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW21		10	616965	6232496					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW22		10	616559	6232794					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW23		10	616002	6233031					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW24	Peace River Transect 5	10	613099	6235624					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW25		10	612727	6236012					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW26		10	612220	6236478					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW27		10	611697	6236730					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW28		10	610982	6236991					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW29	No	10	597439	6231064					Surveyed	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.
	PRSW30	No	10	598178	6232247					Surveyed	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.

Survey Area	Station	Accompanying Transect	UTM Coordinates			Survey Year							
			Zone	Easting	Northing	2016	2017	2018	2019	2020	2021	2022	2023
	PRSW31	No	10	600081	6233281					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW32	No	10	602255	6233351					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW33	No	10	606725	6234293					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW34	No	10	607721	6235469					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW35	No	10	609368	6236803					Surveyed	Surveyed	Surveyed	Surveyed
	PRSW36	No	10	598278	6232689					Surveyed - Called HRSW04 in the field.	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.
Moberly River	MRSW01	No	10	628328	6230312				Surveyed	Active Construction	Active Construction	Active Construction	Active Construction
Bear Flats	BFSW01	Bear Flats Transect	10	611077	6237965				Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	BFSW02		10	611561	6237465				Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	BFSW03		10	612031	6237301				Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	BFSW04		10	612483	6237076				Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
	BFSW05		10	612839	6236812				Surveyed	Surveyed	Surveyed	Surveyed	Surveyed
Cache Creek	CCSW01	Cache Creek Transect	10	607653	6239245				Surveyed	No Access due to high water levels	Active Construction	Active Construction	Active Construction
	CCSW02 / CCSW02B		10	608345	6239034				Surveyed	Surveyed	Active Construction	Active Construction	Active Construction
	CCSW03		10	608729	6238798				Surveyed	Surveyed	Active Construction	Active Construction	Active Construction
	CCSW04		10	609093	6238402				Surveyed	Surveyed	Active Construction	Active Construction	Active Construction
	CCSW05		10	609318	6237699				Surveyed	Surveyed	Active Construction	Active Construction	Active Construction
	CCSW06	No	10	609057	6237557					Surveyed	Active Construction	Active Construction	Active Construction
	CCSW07	No	10	608790	6237457						Established to replace CCSW06	Surveyed	Surveyed
Halfway River	HRSW01 / HRSW01-2	No	10	595783	6231568				Surveyed	Surveyed	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.
	HRSW02	No	10	596262	6231237				Surveyed	Active Construction	Active Construction	Active Construction	Active Construction
	HRSW03	No	10	595800	6231049				Surveyed	Active Construction	Active Construction	Active Construction	Active Construction
Lynx Creek	LCSW01	No	10	571702	6214556					Surveyed	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area	Not surveyed. Site not within Headpond Area
	LCSW02	No	10	572132	6214265					Surveyed	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.	Not surveyed. Site not within Headpond Area.

Footnotes:

General - Green cell indicates the site was surveyed. Red cell indicates the site was not surveyed

* Surveys of the mitigiation areas will be performed again when the reservoir has been inundated or when there are substantial land use changes or habitat modifications.

APPENDIX C
PROJECT QUALIFIED ENVIRONMENTAL PROFESSIONALS

Name and Affiliation	Project Role
Jeff Matheson, M.Sc., R.P.Bio. Tetra Tech Canada Inc.	Project Manager, Report Reviewer
Elyse Hofs, B.Sc., Dipl.T., B.I.T. Tetra Tech Canada Inc.	Field Data Collection, Data Entry, Report Author
Natasha Gidluck, B.Sc., B.I.T. Tetra Tech Canada Inc.	Field Data Collection

APPENDIX D
LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

NATURAL SCIENCES

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of Saulteau EBA Environmental Services Joint Venture's (SEES JV) Client (the "Client") as specifically identified in the SEES JV Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). SEES JV does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by SEES JV.

Any unauthorized use of the Professional Document is at the sole risk of the user. SEES JV accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where SEES JV has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

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The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of SEES JV. Additional copies of the Document, if required, may be obtained upon request.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where SEES JV submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed SEES JV's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by SEES JV shall be deemed to be the original. SEES JV will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of SEES JV's Instruments of Professional Service shall not, under any circumstances, be altered by any party except SEES JV. SEES JV's Instruments of Professional Service will be used only and exactly as submitted by SEES JV.

Electronic files submitted by SEES JV have been prepared and submitted using specific software and hardware systems. SEES JV makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by SEES JV for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of SEES JV.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with SEES JV with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for SEES JV to properly provide the services contracted for in the Contract, SEES JV has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO SEES JV BY OTHERS

During the performance of the work and the preparation of this Professional Document, SEES JV may have relied on information provided by third parties other than the Client.

While SEES JV endeavours to verify the accuracy of such information, SEES JV accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to SEES JV at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

SEES JV is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL ISSUES

The ability to rely upon and generalize from environmental baseline data is dependent on data collection activities occurring within biologically relevant survey windows.

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design or scope, in consideration of the level of the environmental baseline information that was reasonably acquired to facilitate completion of the scope.

1.8 NOTIFICATION OF AUTHORITIES

SEES JV professionals are bound by their ethical commitments to act within the bounds of all pertinent regulations. In certain instances, observations by SEES JV of regulatory contravention may require that regulatory agencies and other persons be informed. The client agrees that notification to such bodies or persons as required may be done by SEES JV in its reasonably exercised discretion.

Appendix 8. Portage Mountain Bat Studies 2023 Annual Report

Draft Report

Site C Wildlife Monitoring –
Portage Mountain Bat Studies: 2023 Annual Report

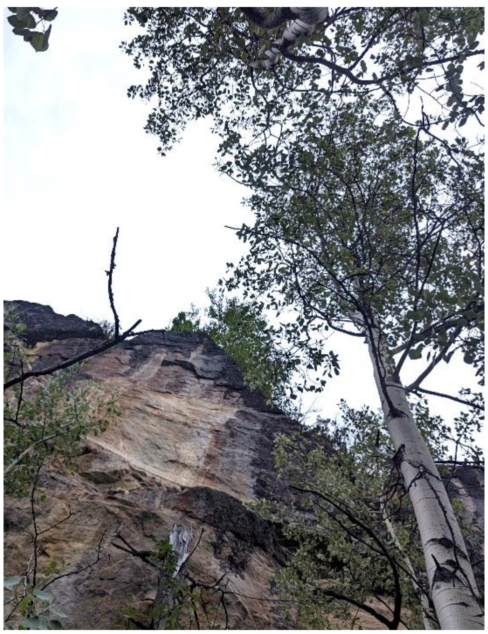

Photo Credit: F. Martinez-Nunez

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Executive Summary

BC Hydro's quarry on Portage Mountain, developed and operated between 2019 and 2021, supplied blast rock and fill materials for the Site C Clean Energy Project. The quarry is close to rock crevice habitat that is highly suitable for bats and is used by federally designated at-risk bat species. The Portage Mountain quarry operated under spatial and temporal constraints intended to minimize impacts on bats and bat habitat. Starting in 2016, BC Hydro undertook bat monitoring as part of its bat mitigation and monitoring plan, with the objective of collecting data to identify and characterize impacts to bats and bat habitat due to quarry construction and assess the effectiveness of mitigation. Annual reports of monitoring results have been produced since 2016 and a comprehensive report was produced in early 2022 that synthesized all available monitoring data to late 2021.

This 2023 annual report summarizes the methods and results of 2023 monitoring at Portage Mountain. It also summarizes methods and results to date of bat acoustic data collection undertaken by the province at five sentinel sites in northwestern British Columbia that will be used to provide comparative data on bat activity to be used in future comprehensive monitoring reports.

Bats were monitored at Portage Mountain year-round between late 2021 and late 2023 using emergence counts and remote acoustic detectors. Emergence counts were used to monitor roost site use, including two suspected maternity roosts. Remote acoustic detectors provided continuous, long-term monitoring of bat activity at Portage Mountain.

Bats were observed emerging at two of the three potential maternity roosts monitored in 2023. Two Portage Mountain acoustic detectors had data gaps of a total of 51 days. Bats in the *Myotis* genus were the species group most commonly recorded at Portage Mountain during the 2022 to 2023 field season. Based on the acoustic detections of *Myotis* and big brown bat (*Eptesicus fuscus*) files during 2022/2023, bats continue to use the habitat at Portage Mountain.

The five sentinel site detectors were active from Spring 2022 to mid-July or early August 2022 for sampling periods ranging from 108 to 167 days. The detectors were re-deployed in October or November of 2022 and operated until the end of April 2023, except for the Bergeron detector which failed immediately after its deployment in November 2022. Big brown bat was assigned to the largest number of bat call files at the sentinel sites. Eastern red bat (*Lasiurus borealis*), silver-haired bat (*Lasionycteris noctivagans*), hoary bat (*Lasiurus cinereus*), little brown myotis (*Myotis lucifugus*), long-eared myotis (*Myotis evotis*), northern myotis (*Myotis septentrionalis*) and long-legged myotis (*Myotis volans*) were also confirmed. Broad trends in bat activity between sentinel sites and Portage Mountain are compared.

This work was performed in accordance with Purchase Order 4130005798 under Master Service Agreement 95055 between Ausenco Sustainability ULC, a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and BC Hydro (Client), dated March 31, 2022. This report has been prepared by Ausenco, based on fieldwork conducted by Ausenco, for sole benefit and use by BC Hydro. In performing this work, Ausenco has relied in good faith on information provided by others and has assumed that the information provided by those individuals is both complete and accurate. This work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work

and project terms of reference; further, the findings are time sensitive and are considered valid only at the time the report was produced. The conclusions and recommendations contained in this report are based upon the applicable guidelines, regulations, and legislation existing at the time the report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

This Executive Summary is not intended to be a stand-alone document, but a summary of findings as described in the following Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

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List of Acronyms and Abbreviations

Acronym / Abbreviation	Definition
BC	British Columbia
BMP	Best Management Practice(s)
BWBSmw	Boreal White and Black Spruce moist, warm subzone
WBWSwk1	Boreal White and Black Spruce wet, cool Murray subzone variant
NA	Not applicable
quarry	Portage Mountain Quarry
Project	Site C Clean Energy Project
study area	Portage Mountain Quarry and adjacent cliffs
SARA	*Species at Risk Act*
NABat	North American Bat Monitoring Program

List of Symbols and Units of Measure

Symbol / Unit of Measure	Definition
%	per cent
km	kilometre
m	metre
n	number

1.0 Introduction

Portage Mountain, approximately 15 kilometres (km) west of Hudson's Hope in northwestern BC (**Figure 2-1**), is the site of a quarry developed to supply aggregate for the construction of the Site C Clean Energy Project in the Peace River valley. The Portage Mountain Quarry provided riprap material used for constructing the Highway 29 realignment and protecting the shoreline along the Peace River near Hudson's Hope during the eventual filling of the reservoir. The quarry ceased operation in 2021.

Baseline studies for the Site C Clean Energy Project (Andrusiak 2014; Simpson et al. 2013), as well as subsequent surveys (Sarell and Alcock 2017), identified cliff faces at Portage Mountain as hibernation and roosting habitat for bats, including two at-risk bat species: little brown myotis (*Myotis lucifugus*) and northern myotis (*Myotis septentrionalis*), listed as endangered on Schedule 1 of the federal *Species at Risk Act* (SARA). Little brown myotis is also provincially Blue-listed (Special Concern). Disturbance of bats during winter may cause them to arouse from hibernation and repeated arousals in response to disturbance are considered detrimental to their survival (Boyles 2017; Sheffield et al. 1992; Thomas 1995).

The potential effects of development and operation of the Portage Mountain Quarry (**Figure 2-1**) on nearby bats were assessed in the Site C Environmental Impact Statement (BC Hydro 2013) and monitoring and mitigation for bats is required by the provincial Environmental Assessment Certificate, the Federal Decision Statement, and Schedule A of the Project's conditional water licences. BC Hydro implemented mitigation actions (BC Hydro 2020) during the quarry's development and operation to minimize the potential for impacts on bats, including the following:

- spatial setback of quarry activities from roost sites; and
- temporal restrictions on high-intensity noise or vibration (i.e., blasting) from 15 September to 15 May to avoid disturbing bats during winter hibernation.

The objective of monitoring bat activity at Portage Mountain is to collect data to help identify and characterize any impacts to bats and bat habitat due to the construction and operation of Portage Mountain Quarry, as described in the *Bat Mitigation and Monitoring Plan* (BC Hydro 2020), which allows the efficacy of mitigation and previous predictions of impacts to be tested. Bat-related monitoring at Portage Mountain over the years has used the following general approaches:

- monitoring of noise and vibration from construction activities, including blasting, to assess whether the disturbance is within best management practices (BMP) guidelines (MOE 2016c) and evaluate whether there are significant relationships with bat activity patterns.
- emergence counts (**Section 4.2.1**) at identified maternity roosts (9427G and 6287F; **Figure 2-1**).
- additional emergence counts at roosts not yet determined to be occupied by maternity colonies (**Section 4.2.1**).
- roost monitoring using remote logger devices (**Section 4.3.2**) to sample activity, temperature, and humidity at the identified maternity roosts.
- long-term, year-round passive acoustic monitoring (**Section 4.3**) using remote bat detectors at the north and south cliffs and near the quarry. Data from acoustic monitoring provide ongoing documentation of bat species presence and activity to assess seasonal and year to year changes in bat activity and potential effects of quarry operation on bat activity and species presence.

Using funds provided by BC Hydro, the province began bat acoustic monitoring at five sentinel sites (i.e., control sites) in northeastern BC in fall 2020. The sentinel sites provide comparative data that can be used to assess trends in activity of bats at Portage Mountain. No in-depth comparisons of the sentinel data and the Portage Mountain data are presented in this report. This report summarizes the results of bat monitoring at Portage Mountain from late fall 2022 to late fall 2023 undertaken to meet the objectives of the *Bat Mitigation and Monitoring Plan* (BC Hydro 2020) and the methods and results of the sentinel site monitoring from its start in 2021 until fall 2023.

2.0 Study Areas

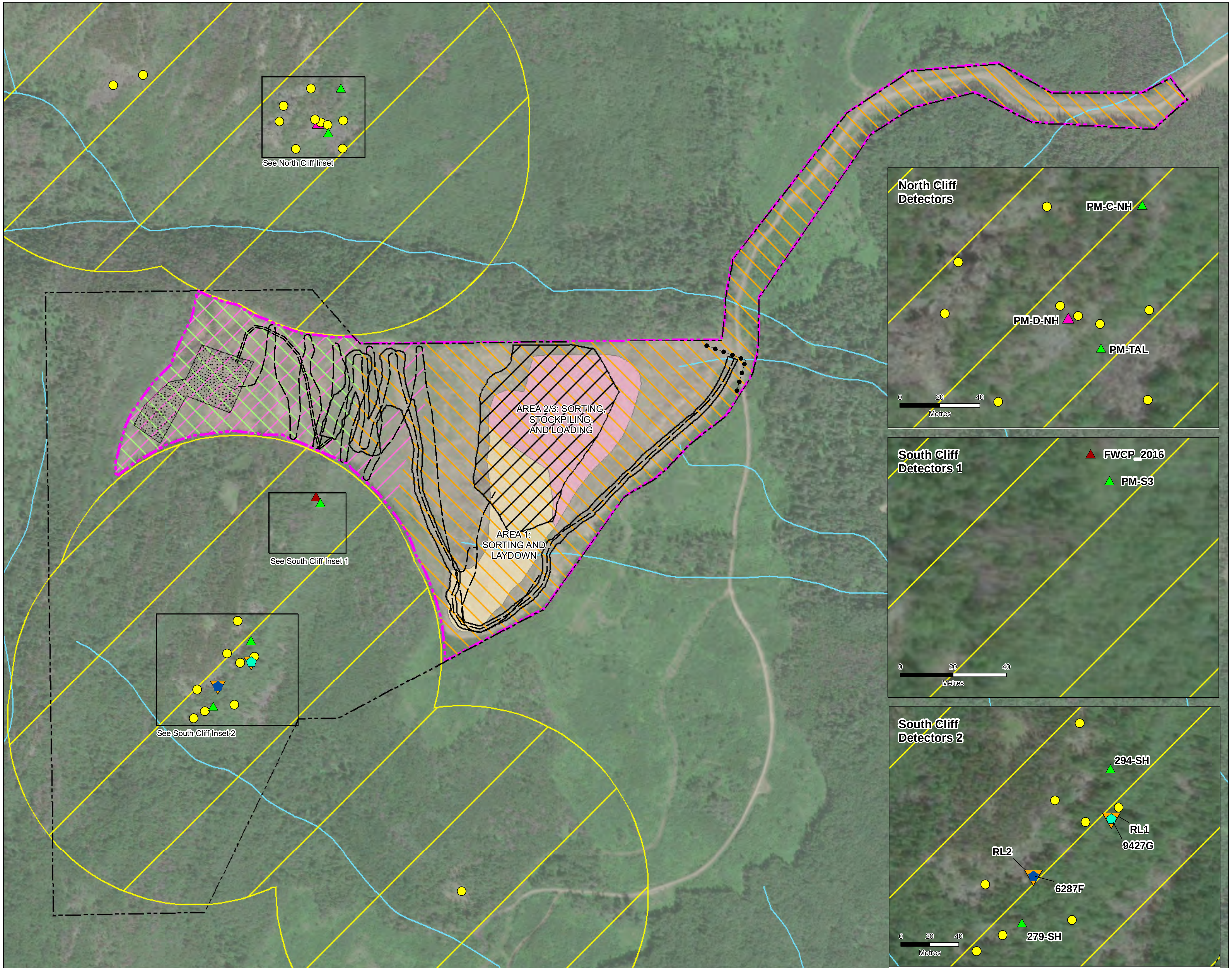
The study areas consist of the Portage Mountain study area, in which bat activity has been monitored continuously since 2017, and the sentinel sites, at which bat activity has been monitored since 2021.

2.1 Portage Mountain Study Area

The Portage Mountain study area has been described in Hemmera (2020) and is briefly summarized here. The bat monitoring study area (**Figure 2-1**) includes the quarry (BC Hydro 2020) and the adjacent cliffs to the north and south within approximately 750 metres (m) of the quarry. This study area has the following characteristics indicative of potential bat hibernacula (MOE 2016a, 2016b; Nagorsen et al. 1993):

- large and exposed (i.e., sparsely vegetated) rock features that gain and maintain solar insolation and have numerous crevices; and
- deep crevices and caves (including mine adits) that provide cool and stable temperatures and high humidity for hibernating bats.

The Portage Mountain cliffs are located within the Boreal White and Black Spruce moist, warm (BWBSmw) biogeoclimatic subzone variant, in forest dominated by hybrid white spruce (*Picea engelmannii* x *glauca*) and trembling aspen (*Populus tremuloides*). The two main areas of cliff (north and south) are separated by an unnamed creek gully that drains into Dinosaur Reservoir (**Photo 2-1**). A stand of mature balsam poplar (*Populus balsamifera*) is present within the gully. Development of the Portage Mountain quarry, located on the south side of the creek gully, began in 2017 with clearing and access road construction. Production blasting and extraction of quarry rock began in the summer of 2019 and ceased in 2021. Further details of quarry activities are provided in **Section 3.2**. The quarry is accessed by a forestry road (400 Road) and is located at an average elevation of 1,020 m.



Site C Clean Energy Project
Wildlife Mitigation and Monitoring Services

Study Area and Bat Detector Locations for Portage Mountain Bat Monitoring

WEATHER STATION

Site Location

0 10 20
Kilometres

Legend

- Permanent Bat Detector
- Bat Detector (Historic)
- Short-Term Bat Detector
- Confirmed Maternity Roost
- Potential Hibernacula
- Potential Maternity Roost
- Roost Logger
- Weather Station
- Security Fencing
- In Quarry Access Road
- Quarry Haul Road
- Stockpile Road
- Site Boundary
- Potential Hibernacula - 300m Buffer
- Portage Mountain LOO
- Stripping/Overburden Stockpile Area
- Quarry Road
- Stockpile & Sort Area
- Quarry Development Area
- Grubbing Area by BC Hydro
- Clearing Area by BC Hydro
- Area 1: Sorting and Laydown
- Area 2/3: Sorting, Stockpiling, and Loading

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Base Data: BC Hydro, 2017
- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

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989619-10	Production Date: Feb 10, 2022	Figure 2.1

Hemmera An Ausenco Company

BC hydro

Photo 2-1 Portage Mountain Quarry, Gully and North Cliffs

2.2 Sentinel Sites

The sentinel sites (**Figure 2-2**) are five locations at which bats were monitored in northwestern BC, summarized in **Table 2-1**. The Rainbow Rocks (Williston Lake) site (**Photo 2-2**) is located northwest of Portage Mountain. Two sites, Bear Flats (**Photo 2-3**) and Tea Creek (**Photo 2-4**), are located along the Peace River valley northeast of Portage Mountain. The Hasler Bluffs (**Photo 2-5**) and Bergeron Cliffs (**Photo 2-6**) sites are located to the south of Portage Mountain. All but one of the sentinel sites are in the BWBSmw; the Bergeron Cliffs site is located in the Boreal White and Black Spruce wet cool Murray (BWBSmk1) variant.

Table 2-1 Bat Monitoring Sentinel Sites

Sentinel Site	Approximate Distance from Portage Mountain Quarry (km)	Biogeoclimatic Subzone Variant	Approximate Elevation (m)
Rainbow Rocks (Williston Lake)	26	BWBSmw	840
Bear Flats	67	BWBSmw	760
Tea Creek	76	BWBSmw	700
Hasler Bluffs	43	BWBSmw	660
Bergeron Cliffs	113	BWBSwk1	1,100

Site C Clean Energy Project
Wildlife Mitigation and Monitoring Services

Figure 2-2 Bat Detector Locations - Sentinel Sites

Legend
- Portage Mountain Quarry
- Sentinel Site
- Weather Station
- Site C Dam Site
- Geographic Location
- Highway
- Provincial Boundary

Notes
1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources
- Contains information licensed under the Open Government Licence - Province of British Columbia
- Base Data: BC Hydro, 2017
- Aerial Image: World Topo Base

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989619-10	Production Date: Mar 15, 2023	Figure 2.2

Ausenco BC hydro

Photo 2-2 Rainbow Rocks Monitoring Location, April 2020

Photo 2-3 Bear Flats Monitoring Location, April 2020

Photo 2-4 Tea Creek Monitoring Location, April 2020

Photo 2-5 Hasler Bluffs Monitoring Location

Photo 2-6 Bergeron Cliffs Monitoring Location

3.0 Background

Bat baseline studies were conducted from 2012 to 2014 at Portage Mountain to support the development of the Environmental Impact Statement for the Site C Clean Energy Project. Those studies determined that some rock features in the vicinity of the proposed quarry area were highly suitable for hibernating bats (Andrusiak 2014). Two at-risk bat species are known to be present at Portage Mountain and are very likely hibernating based on the dates of detections: little brown myotis and northern myotis. Both species are listed as endangered on Schedule 1 of the SARA and both have been confirmed to use rock crevices for hibernation (COSEWIC 2013; White et al. 2020). Based on previous surveys and the characteristics of the habitat, rock crevices used by little brown myotis and northern myotis for hibernation at Portage Mountain meet the criteria for critical habitat under the SARA (COSEWIC 2013). Six other bat species have been recorded at Portage Mountain, at least four of which are likely hibernating and all of which could be using maternity roosts (trees and rock crevices) in the vicinity of Portage Mountain (**Table 3-1**). Based on known bat distributions (Lausen et al. 2022), a similar suite of species is expected to be present at the sentinel sites.

Table 3-1 Bat Species* Previously Recorded at Portage Mountain**

English Name	Scientific Name	BC Status	SARA Schedule 1 Status	Winter Behaviour
Long-eared myotis	*Myotis evotis*	Yellow	None	Hibernate
Little brown myotis	*Myotis lucifugus*	Blue	Schedule 1 Endangered	Hibernate
Northern myotis	*Myotis septentrionalis*	Blue	Schedule 1 Endangered	Hibernate
Long-legged myotis	*Myotis volans*	Yellow	None	Hibernate
Silver-haired bat	*Lasionycteris noctivagans*	Yellow	None	Hibernate or Migrate
Eastern red bat	*Lasiurus borealis*	Unknown	None	Migrate
Hoary bat	*Lasiurus cinereus*	Yellow	None	Migrate
Big brown bat	*Eptesicus fuscus*	Yellow	None	Hibernate

Notes: *English and scientific names are those used by the BC Conservation Data Centre (BC CDC 2023)
**(Andrusiak 2014; Hemmera 2018, 2020; Sarell and Alcock 2017)

The bat studies conducted since 2014 (Andrusiak 2014; Hemmera 2018, 2020; Sarell and Alcock 2017) used a combination of passive acoustic surveys and emergence surveys to build an understanding of bat activity and habitat use, and provide strong evidence that bats are using Portage Mountain rock crevices for the following:

- hibernacula in the winter (typically both sexes, likely in small groups).
- maternity roosts in the summer where breeding females congregate to gestate, give birth, and raise young.
- day roosts, in the spring, summer, and fall, used by single individuals or small groups of males or of non-reproductive females.

BC Hydro prepared a bat monitoring plan in 2017, which was updated in 2020 (BC Hydro 2020) with input from the Site C Clean Energy Project's Vegetation and Wildlife Technical Committee.

The current bat monitoring program at Portage Mountain (**Table 3-2**) consists of:

- year-round acoustic monitoring
- emergence counts at maternity roosts during the summer.

Noise monitoring also took place while the quarry was operational.

Monitoring studies (Hemmera 2018, 2020) were designed to determine the efficacy of mitigation implemented during construction and operation of the Portage Mountain quarry to reduce the disturbance or displacement of bats that use rock crevices as maternity roosts and/or hibernacula (**Figure 2-1**; **Table 3-2**). A comprehensive report (Hemmera 2022) was prepared in early 2002 that summarized all bat data collected at Portage Mountain between August 21, 2017 and November 3, 2021. The province began bat acoustic monitoring at five sentinel sites in 2021 (**Table 3-2**).

Table 3-2 Bat Monitoring Program Components Conducted at Portage Mountain and Sentinel Sites

Monitoring Activity	2017	2018	2019	2020	2021	2022	2023
Portage Mountain							
Passive Acoustic Bat Activity	X	X	X	X	X	X	X
Maternity Roost Emergence Counts and Roost Inspection	X	X	X	X	X	X	X
Noise and Vibration	–	X	X	X	X	-	-
Sentinel Sites							
Passive Acoustic Bat Activity	–	–	–	–	X	X	X

Note: X = surveys were conducted, – = surveys were not conducted.

3.1 Known and Suspected Hibernacula and Maternity Roosts

Early studies identified sections of the Portage Mountain cliffs adjacent to the quarry as potential hibernacula (Andrusiak 2014; Sarell and Alcock 2017). Hemmera (Hemmera 2018, 2019, 2020) conducted passive acoustic monitoring over multiple years and identified peaks of bat activity during the mating period in the fall (swarming), some winter bat activity, and activity in the spring when bats start emerging from hibernation, supporting the conclusion that bats were hibernating at the cliff features at Portage Mountain.

Early studies also identified use of the cliffs as day roosts (Hemmera 2018, 2020). Emergence counts conducted in 2017 through 2021 (**Table 3-3**) identified potential maternity roosts (6287F, 9247G) in the cliffs south of the quarry (**Figure 2-1**) based on multiple individuals observed exiting the cliffs during emergence counts. Other counts identified areas of the cliff where smaller numbers of bats were observed emerging. However, finding specific roost crevices in the cliffs is difficult due to the presence of multiple crevices in close proximity, the height above ground of many crevices, and the steep and hazardous terrain that prevents surveyors from closely approaching crevices. Bats may also roost in the trees on Portage Mountain.

Table 3-3 Emergence Counts Previously Conducted at Portage Mountain

Year	Dates of Emergence Counts
2017	• July 31 to August 10
2018	• June 17 to June 20 • June 30 to August 03
2019	• June 09 to June 13 • June 19 • July 22 to July 25
2020	• June 22 to June 28 • July 14 to July 20
2021	• June 14 to June 20 • July 13 to July 20
2022	• June 7 to June 11 • July 26 to August 01

3.2 Quarry Construction and Operation Activities and Bat Mitigation

Quarry construction and operation activities within the quarry boundaries (**Figure 2-1**) between 2019 and 2022 included the following:

- developing and upgrading road access;
- clearing vegetation in the quarry area;
- blasting, excavating, and transporting material; and,
- rock sorting (in the lower area close to 400 Road).

Construction activities for road access, vegetation clearing, and the haul road began in 2016 and were completed in fall 2019 (**Table 3-4**). In 2020, riprap loading and sorting and tree clearing continued, and nighttime activities took place from July 1 to October 9. Production blasting occurred during 2020 and 2021, ceasing in mid-August 2021. Additional processing and loading continued into June 2022, and maintenance and cleanup and reclamation activity (BC Hydro 2023) has occurred periodically at the quarry since then.

Table 3-4 Quarry Construction and Operation Activities 2017- 2023

Dates	Location *	Activity
2016	Access road and quarry site	Clearing and access road construction
August 10 to August 14, 2018	Future quarry site	Test blasting
June 6 to September 15, 2019	Quarry and along 400 Road	Tree clearing
June 6 to August 20, 2019	Quarry	Blasting for haul road construction
August 21 to September 15, 2019	Pit	Production blasting
May 16 to September 14, 2020	Pit	Production blasting
May 16 to early November, 2020	Quarry, Stockpile and Sorting Area (Area 1) to Offsite Rip Rap Stockpile Area (Area 4)	Tree clearing
May 16 to early November 2020	Area 1 to Area 4	Riprap loading and sorting
July 1 to August 18, 2020	Area 1 to Area 4	Nighttime hauling
July 22 to August 18, 2020	Pit to Area 1	Nighttime hauling with vehicle lights only
July 22 to August 18, 2020	Pit	Nighttime excavation at the pit
August 9, 2020	Area 1	Installation of lights for safety at nighttime
August 28 to October 9, 2020	Area 1 to Area 4	Nighttime hauling
May 16 to August 17, 2021	Pit	Production blasting
March to April, 2021	Area 5	Clearing, grubbing, stripping and hauling
May to August, 2021	Area 1 to Area 4	Nighttime hauling in areas 1 and 4
September to December, 2021	Area 1	Processing material
March to June, 2022	Area 2 and 3	Load remaining material for berm construction
June 2022	All	Construct water bars and site cleanup
October 2022	All	Additional cleanup, dig out settling ponds, water bar maintenance
2023	All	Additional cleanup

Note: *See **Figure 2-1**.

4.0 Methods

Methods implemented at Portage Mountain from 2017 through 2023 were developed in consultation with the Vegetation and Wildlife Technical Committee and local biologists (Hemmera 2018). Methods are based on standard techniques used for bat studies (Bachen et al. 2020; BC Ministry of Environment 2016b), with minor variations to account for the specific habitats, terrain, and access challenges at the monitoring sites.

4.1 Weather and Sunset Data

BC Hydro provided hourly weather data from their weather station at the Portage Mountain quarry (**Figure 2-1**). Sunset and sunrise times for Fort St. John were obtained from National Research Council (2023).

4.2 Portage Mountain Roost Emergence Counts, Roost Inspections, and Maternity Roost Monitoring

Bats consistently emerge from maternity roosts at dusk for feeding, which provides opportunities for roost identification and enumeration of bats via emergence counts. Roosts used by pregnant and nursing female bats have more regular patterns of emergence than roosts used by male or non-reproductive individuals (Barclay 1989; MOE 2016b). The objectives of the emergence surveys were to identify maternity roosts, to assess potential changes in use of the cliffs as maternity roosts, and to examine the relationship between any changes in maternity roost use and quarry activity.

Two methods were used to collect emergence data at identified and suspected maternity roosts and non-maternity roosts:

- emergence counts and roost inspections; and
- continual roost monitoring with remote roost loggers placed near the roost entrances to record bat calls.

4.2.1 Portage Mountain Roost Emergence Counts and Roost Inspections

Roost emergence counts were conducted in 2023 at Portage Mountain following methods described in Loeb et al. (2015) and Vonhof (2006). The methods have been previously described in Hemmera (2019). Information on site selection criteria was provided in the 2017 to 2019 bat monitoring report (Hemmera 2020). Physical inspections for roosting bats or bat sign such as guano were conducted where potential features could be safely accessed by surveyors.

Visual emergence counts were completed twice yearly during the maternity period: once (‘early period’) during pre-volancy (i.e., when pups are not able to fly) between June 1 and June 21, and once (‘late period’) during post-volancy (i.e., when pups can fly) from July to early August. Emergence counts were conducted from 30 minutes before dusk until approximately one hour after dusk, when visibility became a limiting factor, or until bats started to return to the roost. Each site on the north and south cliffs was surveyed on two consecutive nights both pre- and post-volancy (four surveys total). Surveyors were equipped with handheld acoustic detectors (Echometer Touch) that recorded bat vocalizations in the vicinity of the surveys. Sites where no bats were observed were not resurveyed in subsequent years.

4.2.1.1 Data Analysis

The numbers of bats observed exiting the cliff at each roost emergence count location on each date were summed. Observations of bats foraging or flying by the observer were not included in the total unless the surveyor had observed the bats emerging from the cliff.

Acoustic data recorded by the Echometer Touch hand-held units during emergence counts were analysed using the same process used for all the other acoustic data analyses in this project (**Section 4.3**). Acoustic data were correlated with the visual observations made by the surveyors based on the location and time of the observations and hand-held unit recordings, as well as the surveyors' comments.

The bat mitigation and monitoring plan (BC Hydro 2020) and previous monitoring reports for Portage Mountain (Hemmera 2020) use a threshold of 10 bats emerging at a given site to define a 'maternity roost', although some of the provincial BMP definitions for a 'significant' roost (**Section 3.1**) specify fewer individuals than the threshold of 10 bats used for this project. Hemmera/Ausenco is not aware of any literature that provides a minimum number of bats that constitute a maternity roost. To maintain consistency through multiple years of data analysis, the 10-bat threshold was used; however, roosts where three to nine individuals were counted were also reported.

The following criteria were used to determine likely maternity roost occupancy:

- at least 10 bats emerging from a single feature during at least one emergence count during the maternity period (assumed to occur from mid-May to mid-August [Paterson, B., pers. comm., July 2019]).
- emergence timing at or near sunset (indicative of lactating females with dependent pups).
- observations of bats returning to the roost (i.e., to feed dependent pups) during the emergence survey.
- a marked increase in count numbers occurring at a single site over the pre-volant to volant period for young-of-year bats, in consideration of other influencing factors such as weather.

Daily emergence at or near sunset may indicate lactating female bats. Lactating bats leave their roosts at or near sunset because the energetic burdens of pregnancy and nursing require them to start foraging early to maximize foraging duration (Henry et al. 2002; Lemen et al. 2016). The daily emergence times of males and non-breeding females are more flexible because they have lower energy demands than lactating females and can use daily torpor to further decrease their metabolic requirements (Kurta et al. 1989; reviewed in Sedgeley 2001). Lactating females must also return to the roost during the night to nurse dependent pups.

The presence of juveniles also provides strong evidence of a maternity roost, at least up to the late summer period. The presence of juveniles in the roost can be inferred by a sudden increase in the number of bats counted during emergence counts late in the summer, when young-of-the-year can fly, compared to the number of bats counted during emergence surveys early in the summer.

4.2.1.2 Assumptions and Data Limitations

The assumptions used in collection and analysis of the emergence count data include the following:

- observers can accurately distinguish between a bat emerging from the cliff and a bat foraging along the cliff.
- vocalizations recorded on the observer's handheld detector at the same time as a visual observation of an emerging bat are those of the bat observed.

The accuracy of emergence counts was limited by physical and weather conditions at the sites monitored. Surveyors had to choose vantage points that were safe for them to access, which often meant that they could not get the best view of emerging bats. Some bats emerged from crevices high on the cliffs and it was difficult for observers at the bottom of the cliffs to see them. Rain and fog impeded visibility on some counts as described in **Section 5.2**. The assumptions related to acoustic data recorded during emergence counts are similar to those described for long-term acoustic monitoring (**Section 4.3**).

4.3 Long-term Passive Acoustic Monitoring

Bioacoustic technology is an efficient, non-invasive tool for examining bat activity patterns and species diversity over long durations. Acoustic detectors provide a metric of bat activity based on the number of bat calls recorded within approximately 50 m (Fraser et al. 2020; Lausen 2016). Year-round acoustic monitoring is used to assess ongoing bat activity and compare that activity between years and annual bat life stages. Acoustic data can be used to confirm the presence of individual species and document any changes in bat species diversity between years. Acoustic data can also be used to infer use of hibernacula. Evidence of hibernation occurring in proximity to the detector includes the following:

- relatively high bat activity recorded during the fall mating and swarming periods;
- limited and localized winter activity; and
- surges of activity during spring emergence.

4.3.1 Portage Mountain Detectors and Detector Locations

The rationale behind selection of locations for long-term bat detectors on the north and south cliffs of Portage Mountain (**Figure 2-1**; 'permanent bat detector') was described in Hemmera (2019).[1]

A single Songmeter detector was installed at each of 4 locations in November 2017 and those locations have been monitored continuously to date, although some data gaps have occurred due to equipment issues (Hemmera 2022). The SM2 detectors installed in 2017 at the beginning of the study period were replaced by new SM4BAT-ZC units equipped with SMM-U1 or SMM-U2 microphones in summer 2019. One detector (NH) was deployed at the north cliff, two (279 and 294) on the south cliff, and one (S3) between the south cliff and the quarry (**Table 4-1**). Those four locations have been monitored year-round from 2017 through 2023. A fifth detector (TAL) was installed on June 26, 2020, upslope from a talus field at the north cliff and has been operating continuously since its installation.

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1 **Figure 2-1** also depicts locations of bat detectors used in earlier investigations of bat activity on Portage Mountain ('historic' and 'short-term' detectors). Names of the long-term passive acoustic monitoring detectors have been simplified from throughout the document.

Table 4-1 Long-term Passive Acoustic Monitoring Sites, 2017 to 2023

Name	General Location	Distance (m) From Closest Quarry Boundary	Comment
NH	North cliff	402	--
TAL	North cliff talus	330	Installed 2020
279	South cliff	401	Suspected maternity roost 6287F
294	South cliff	334	Suspected maternity roost 9427G
S3	Quarry	81	--

Detector settings have been described in Hemmera (2019). Microphones were calibrated in June 2023 to confirm sensitivity within the manufacturer's specified range and to maximize consistency in data collection. The detectors were visited every other month to download data and verify detector operation.

The detectors were prepared for winter with protected microphones and cables, a water- and snow-resistant housing, and a combination battery/solar power supply. Each detector was outfitted with a 12-volt battery (seven amp-hours) powered by a Renogy 100-watt solar panel, and a Morningstar SS 20L-12V SunSaver 20-amp solar charge controller.

4.3.2 Portage Mountain Data Processing

Acoustic data analysis methods used in 2023 were identical to those of 2021 and 2022. The acoustic data analysis followed a conservative approach as recommended by Lausen (2016); only files with two or more echolocation pulses (Vonhof 2006) separated by at least one second (termed a bat 'pass', 'call' or 'file') were included in the analysis and were considered for classification to species level or species group. A series of bat passes could be made by the same bat flying multiple times in front of the microphone or by multiple individuals (Adams et al. 2015); therefore, the results provide a relative index of bat activity (files per detector-night) but do not represent an estimate of bat populations in the study area.

Analysis methods were consistent with those used by the North American Bat Monitoring Program (NABat) as described in Smith (2020). Bat files were classified based on acoustic parameters for the targeted bat species (summarized in **Appendix A**) using two automated species classifications: Kaleidoscope Pro (V5.6.4 Wildlife Acoustics Inc.) and species-specific filters developed for AnalookW V4.5 (Titley Electronics, Ballina, New South Wales, Australia). Noise files, such as ambient background sounds, were excluded from the dataset through Kaleidoscope Pro and a filter in AnalookW. The automated classification results were then manually verified based on professional judgement. Bat calls were either classified according to species or grouped into categories based on their acoustic parameters (**Appendix A**). Files with multiple species or individuals were assigned to each of the relevant categories (i.e., were counted once for each species and individual). Social calls were identified through manual inspection.

The acoustic parameters used for the identification of each call were derived from accepted characteristics based on scientific studies and acoustic libraries (Lausen 2016). Updated provincial bat protocols for acoustic monitoring are not yet available. Therefore, the analysis methods used for 2020 to 2023 data (Hemmera 2018, 2020, 2022), which were developed through consultation between Hemmera and a bat specialist with the BC Ministry of Forest, Lands, Natural Resource Operations and Rural Development (Hansen, I.J., pers. comm., September 2018), were repeated for the 2023 analysis (**Appendix A**).

Bat echolocation calls, especially those from the *Myotis* genus, can be difficult to identify to species due to high variability within species (Obrist et al. 2004) and overlap in call characteristics among some species. Where *Myotis* calls could not be definitively identified to species they were assigned to the *Myotis* category, which is composed of little brown myotis, long-eared myotis, northern myotis, and long-legged myotis because of overlap in call characteristics (**Appendix A**). The *Myotis* category (**Appendix A**) was assumed to indicate the potential presence of the endangered little brown myotis or northern myotis. Similarly, silver-haired and big brown bat are often grouped together, as are eastern red bat and little brown myotis, again because of overlap in call characteristics. Known or potential *Myotis* species files (including all files identified as any of the *Myotis* species, the *Myotis* category, and the 35K eastern red bat/little brown myotis category) were merged into a broader *Myotis* group for analysis. The 'big brown bat' broad species group used for some summaries included files categorized as big brown bat and as big brown bat / silver-haired bat.

A night of monitoring by a single detector was termed a 'detector-night', assigned to the date on which the night began even though the file itself may have been recorded in the early morning of the next day. The numbers of bat passes recorded per detector-night were compared between detectors and over time to examine patterns in bat activity.

An R script was created to identify dates when no bat or noise files were recorded by each detector (i.e., data gap). Each bat file was linked to hourly weather from BC Hydro's Portage Mountain weather station (**Section 4.1**). A subjective number of consecutive days without data was chosen to assess whether a detector was functioning correctly: if no bat calls or noise files were recorded for a period of five nights or more in summer or 20 or more nights in winter, fall, or spring, the detector was considered inactive.

4.3.3 Sentinel Site Detectors and Detector Locations

Bat detectors were deployed at five known bat hibernacula in north-eastern BC (M. Kellner, pers. comm). All five sites represented cliff crevice habitat. Installation and servicing of the sentinel site detectors was carried out by a consultant under contract to the Province, and the information in this section was provided by Brian Paterson (pers. comm. 2022). The original deployment in April 2020 included four Anabat Swift detectors (Titley Scientific Ltd.) with US-0-V1 microphone and one SM2Bat+ detector with an SMX-US microphone (Wildlife Acoustics Inc.). In April 2021, all detectors were replaced with new Anabat Swift units equipped with US-0-V3 omnidirectional microphones and powered by 12-volt lithium batteries attached to 30-watt solar panels. The microphone of the SM2Bat+ was calibrated with the Wildlife Acoustics Inc. ultrasonic calibrator and the Swift units were calibrated using the on-board microphone sensitivity gauge set to 12 and tested using finger snaps and ambient background noise. Microphones were installed on a painter's pole either extended upwards vertically or extended horizontally over the cliff edge. Secure digital (SD) cards with 64 GB capacity were initially installed; these were replaced with 192 GB SD cards in 2022.

The gain of the SM2Bat+ detector was set at 12 kHz (the Swift detectors do not have gain settings). All detectors were programmed to record with a two-second trigger window and maximum file length of 15 seconds. All detectors were set to record full-spectrum files between 16 and 200 kHz from 15 minutes before sunset until 15 minutes after sunset. A summary of the sentinel site detectors and locations is presented in **Table 4-2**.

Table 4-2 Sentinel Site Detector Locations and Specifications

Location	2020 Installation Date	Zone	UTM Easting	UTM Northing	Detector Type	Microphone Type	Microphone Height[1] (m)
Rainbow Rocks	April 12	10V	535294	6220897	Anabat Swift	US-0-V1 US-0-V3 (after Apr 2021)	50
Tea Creek	April 11	10V	624506	6235500	Anabat Swift	US-0-V1 US-0-V3 (after Apr 2021)	40
Bear Flats	April 11	10V	612658	6238223	Anabat Swift	US-0-V1 US-0-V3 (after Apr 2021)	40
Bergeron Cliffs	April 13	10U	625964	6116291	Anabat Swift	US-0-V1 US-0-V3 (after Apr 2021)	45
Hasler Bluffs	April 15	10U	568133	6163616	SM2Bat+ (Apr 2020-Apr 2021) Anabat Swift (from Apr 2021)	SMX-U1 (Apr 2020-Apr 2021) US-0-V3 (after Apr 2021)	40

Notes:
1. Height includes the height of the cliffs on which the microphone was located.

4.3.4 Sentinel Site Data Processing

Classification of the sentinel site bat acoustic data was completed by a contractor chosen by the province. Analysis methods were consistent with those used by NABat (Rae and Lausen 2022) and are described below (B. Paterson, pers. comm. 2022)

> *"Full spectrum data were processed through two auto-ID programs (Kaleidoscope Pro and Sonobat), followed by manual review to identify files with discrepancies or deviations from expected results. Species and species group labels followed BC NABat (Rae and Lausen 2022). Species and classifications were typically given an 'm' or an 'f' prefix to denote whether the analyst (B. Paterson) observed diagnostic characteristics (such as mEPFU) in each file or whether auto-ID was relied on for the classification (such as fEPFU). For final submission, 'm' and 'f' prefixes were removed to streamline results."*

Detector log files were used to quantify sampling effort and identify dates when the detectors were not functioning. The time of sunset and the temperature recorded at the closest weather station were linked to each bat file record as described in **Section 4.3.2** for the Portage Mountain data. The sentinel site data were grouped into the following species groups, which differed from that used for Portage Mountain data:

- Big brown bat
- Big brown and hoary bats
- Big brown, hoary, and silver-haired bats
- Big brown and silver haired bats

- Big brown and long-eared bats
- Little brown myotis
- Little brown and long-legged myotis
- *Myotis* sp.
- Northern myotis
- Long-legged myotis.

4.3.5 Acoustic Data Analysis

The Portage Mountain and sentinel site acoustic data were summarized separately due to differences in the acoustic data classification process and study design (e.g., sampling effort, distance between detectors).

4.3.5.1 Quantifying Bat Activity

To summarize bat activity at the Portage Mountain and sentinel sites during the respective sampling periods, bat activity was calculated as the number of bat call files per active detector-night. This accounts for differences in sampling effort that can occur due to different time periods detectors were active. For Portage Mountain bat activity was summarized by bat species group, detector, and bat life stages. For the sentinel sites, bat activity was summarized as bat call files per species group and detector but not the number of bat call files per active detector night.

5.0 Results

5.1 Portage Mountain Maternity Roost Emergence Counts

Early-season emergence counts took place June 6 to June 11. Wildfire smoke was noted on several nights, and strong winds and light rain on one night (June 9). No precipitation was recorded on the remaining nights. Twelve emergence counts were conducted during early-season surveys, six at the south cliff and six at the north. Temperatures at the start of emergence counts ranged from 16 °C to 20 °C.

Late-season surveys took place July 26 to August 1, excluding July 30. Moderate precipitation was recorded on July 26. Twelve emergence counts were conducted during late-season surveys, eight at the south cliff and four at the north cliff. Temperatures at the start of emergence counts ranged from 15 °C to 20 °C.

Results of the 2023 emergence counts are presented in **Table 5-1**. Bats were counted emerging at four of the 12 early surveys and at ten of the 12 late surveys. Counts at the 9427G roost ranged from 19 to 31 bats during the early surveys and 0 to 1 bat during late surveys. Early season counts at the 6287F roost ranged from zero to two bats and late season counts ranged from two to three bats. No bats were observed during early season counts at the NHEC3b roost, and two bats were recorded there during one of two nights during the late season. No bats were observed at 9399F during early season counts but three and four bats were observed during two late season counts. Bats seemed concentrated within 9427G during the early counts and more dispersed between roosts during the late season counts.

Table 5-1 2023 Emergence Count Results

Date	Location	Location	Survey Period	Emerging Bats Counted
6 June	9427G	south	early	19
6 June	6287F	south	early	0
7 June	6287F	south	early	0
7 June	9427G	south	early	31
8 June	9427G	south	early	29
8 June	6287F	south	early	2
9 June	9399F	north	early	0
9 June	NHEC3b	north	early	0
10 June	NHEC3b	north	early	0
10 June	9399F	north	early	0
11 June	9399F	north	early	0
11 June	NHEC3b	north	early	0
26 July	9427G	south	late	0
26 July	6287F	south	late	2
27 July	9427G	south	late	1
27 July	6287F	south	late	3

Date	Location	Location	Survey Period	Emerging Bats Counted
28 July	6287F	south	late	3
28 July	9427G	south	late	1
29 July	6287F	south	late	3
29 July	9427G	south	late	1
31 July	9399F	north	late	3
31 July	NHEC3b	north	late	2
01 August	9399F	north	late	4
01 August	NHEC3b	north	late	0

5.2 Cumulative Emergence Counts

Thirty-five maternity roost emergence counts have been conducted at the two suspected maternity roosts since 2017 (**Table 5-2**; **Figure 5-1**). The average number of bats counted generally dropped during 2020 and 2021, and then increased again in 2022 and 2023, except for late surveys in 2023 at 9427G.

Table 5-2 Emergence Counts Completed, and Average* Number of Bats by Survey Night, at Two Suspected Maternity Roost Sites on Portage Mountain, 2017-2023

Maternity Roost ID	Session	Average bats counted (number of counts) 2017	Average bats counted (number of counts) 2018	Average bats counted (number of counts) 2019	Average bats counted (number of counts) 2020	Average bats counted (number of counts) 2021	Average bats counted (number of counts) 2022	Average bats counted (number of counts) 2023
9427G	Early	-	41 (2)	15 (3)	4 (2)	14 (2)	13 (5)	26 (3)
	Late	9 (3)	8 (2)	26 (3)	15 (2)	3 (4)	33 (3)	1 (4)
6287F	Early	-	6 (2)	4 (2)	4 (2)	0 (1)	3 (5)	1 (3)
	Late	10 (2)	9 (1)	0	-	2 (2)	2 (3)	3 (4)

*as sample sizes are small, no measure of variance has been calculated

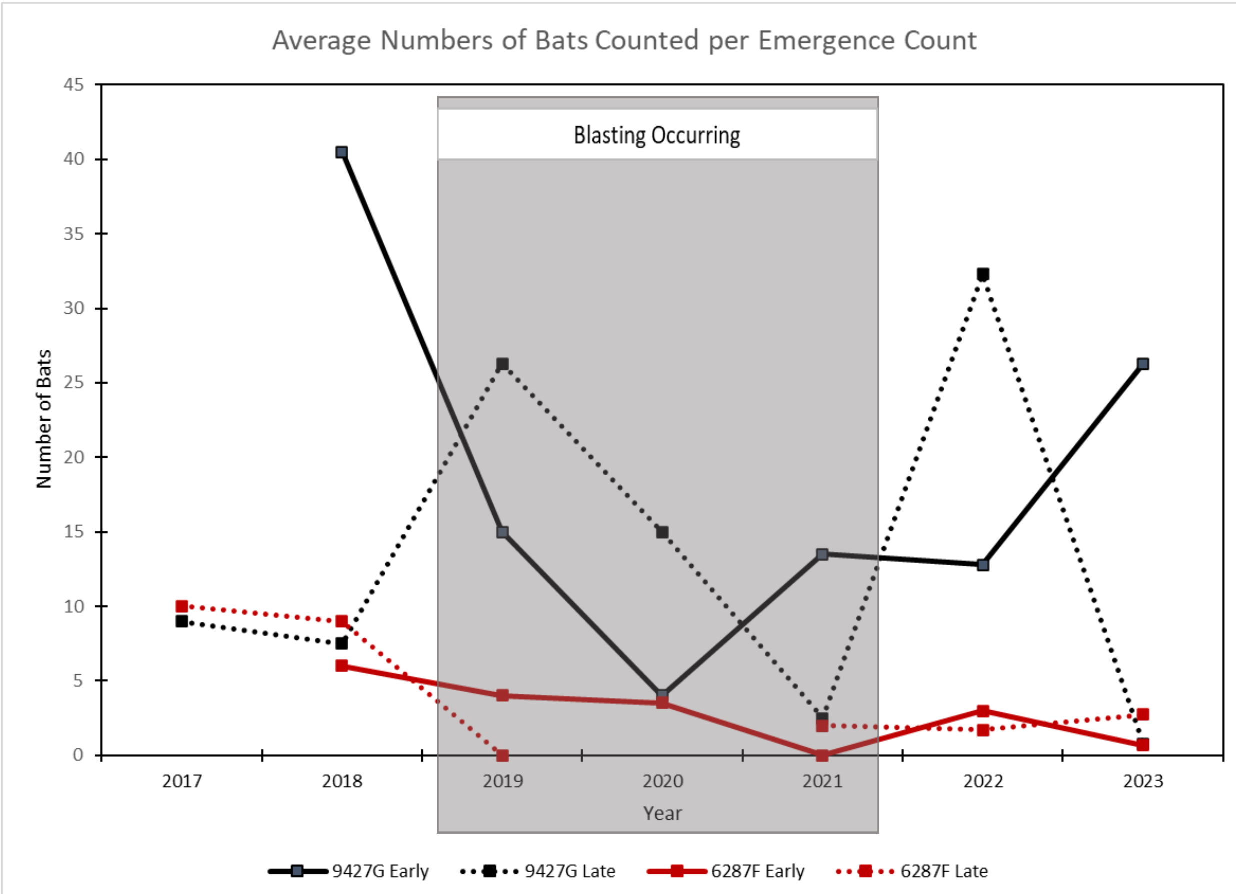

Figure 5-1 Average Number of Bats Counted at Two Roosts from 2017 to 2023

5.3 Long-term Passive Acoustic Monitoring

Results of acoustic monitoring at Portage Mountain and the five sentinel sites are presented below.

5.3.1 Portage Mountain Acoustic Results

A summary of cumulative survey effort for the 2022 - 2023 season at Portage Mountain is available in **Table 5-3**. The five permanent detectors recorded data on 1,197 detector-nights between January 24, 2023 and October 13, 2023. Raw data from the wintering period of November 14, 2022 to January 24, 2023 was not processed, inadvertently. Nonetheless, this timeframe typically corresponds to a phase of zero activity, or minimal in some cases. Despite this, the data encompassing most of the winter months, specifically January and February, and data pertaining to winter emergence, has been successfully processed and included in the analysis.

Table 5-3 Remote Detector Survey Effort (Nights When Detectors Were Operating) at Portage Mountain During the 2022 – 2023 Field Season

Detector	Detector- Nights
279	262
294	186
NH	260
S3	263
TAL	226
Total Detector Nights	**1197**

A summary of the data gaps by date is presented in **Table 5-4**. Only detector NH and TAL had data gaps during the 2022 – 2023 season. Data gaps for TAL are due to decreased bat activity (trigger windows not activated with noise etc. due to greater sound protection as it's aimed at talus slope with less vegetation than other detectors). NH detector had a new solar panel and cables installed in November 2022. The log files from these two detectors were reviewed and confirmed that they were functional during this period.

Table 5-4 Timing of Data Gaps by Detectors at Portage Mountain During the 2022 – 2023 Field Season

Detector	Data Gap Dates	Gap Length (Nights)
NH	March 31, 2023 – April 10, 2023	4
TAL	January 28, 2023 – April 22, 2023	38
TAL	June 18, 2023 – October 2, 2023	9
Total	-	**51**

Bats in the *Myotis* genus were the most commonly recorded species group at Portage Mountain during the 2022 – 2023 field season, followed by the big brown & silver-haired bat species group (**Table 5-5**). The *Myotis* species group, which in **Table 5-6** contains the endangered little brown myotis and Northern myotis, was most detected at 279, followed closely by NH, which were located furthest to the quarry from the North and South sides, respectively.

Table 5-5 Number of Files per Species Group Recorded by All Detectors at Portage Mountain During the 2022 – 2023 Field Season

Species Group	Number of Files	Files per Active Detector-night
Big brown	4172	14
Big brown & silver-haired	31941	91
Eastern red	1046	6
Hoary	369	2
Myotis	81627	378
Northern myotis	608	3
Long-eared myotis	7759	25
Little brown myotis	1878	6

Species Group	Number of Files	Files per Active Detector-night
Red bat & little brown myotis	1635	8
Silver-haired	1256	5
Total	132291	538

Table 5-6 Number of Files per Detector and Bat Species Group at Portage Mountain During the 2022 - 2023 Field Season

Detector	Species Group	Number of Files	Files per active detector night
279	Big brown	2327	9
	Big brown & silver-haired	11706	35
	Eastern red	355	2
	Hoary	149	2
	Myotis	35723	143
	Silver-haired	323	3
294	Big brown	810	6
	Big brown & silver-haired	8719	38
	Eastern red	105	2
	Hoary	32	1
	Myotis	9172	70
	Silver-haired	413	8
NH	Big brown	462	3
	Big brown & silver-haired	3514	17
	Eastern red	203	3
	Hoary	50	1
	Myotis	26593	113
	Silver-haired	186	4
S3	Big brown	297	3
	Big brown & silver-haired	4768	11
	Eastern red	214	2
	Hoary	54	1
	Myotis	15559	55
	Silver-haired	286	5
TAL	Big brown	276	2
	Big brown & silver-haired	3234	12
	Eastern red	169	2
	Hoary	84	1
	Myotis	5489	27
	Silver-haired	48	4

*Myotis group in Table 5-6 includes (Northern myotis, long-eared myotis, little brown myotis) and red bat & little brown myotis calls were removed for simplicity.

5.3.2 Sentinel Site Acoustic Results

The sentinel site detector dataset obtained by Ausenco in November 2023 consisted of identifications of files from the five sentinel sites dating from spring, summer and fall 2022 and spring 2023. The sentinel site detectors were active from the end of March to mid-July or early August 2022 for sampling periods ranging from 108 to 167 days. The detectors were re-deployed in October or November of 2022 and operated until the end of April 2023, except for the Bergeron detector which failed immediately after its deployment in November 2022. The sentinel detectors were not active during the swarming period (late summer to early fall).

Two data gaps were identified in 2022; a 6-night period between April 12 and April 17 inclusive for Bergeron, and a 5-night period between April 11 and April 15 inclusive for Rainbow Rocks. A summary of sentinel site detector downloads in all years is presented in **Table 5-7**. The five detectors recorded data on 1363 detector-nights (686 detector-nights from March to July or August 2022, and 677 detector-nights from November 2022 to the end of April 2023).

Table 5-7 Sentinel Site Detector Sampling Effort Summary

Location	Year	Detector Type	Sampling Start Date	Sampling End Date	Active Detector Nights	Number of Bat Files	Bat Files/ Detector Night
Bear Flats	2020	Swift	April 11	August 5	117	17,296	147.8
	2021	Swift	April 15	June 24	70	14,194	202.8
	2022	Swift	March 3	August 16	167	50,770	304.0
		Swift	November 23	December 31	33	557	16.9
	2023	Swift	January 1	April 30	111	8,627	77.7
Bergeron Cliffs	2020	Swift	April 13	October 11	180	6,919	38.4
	2021	Swift	April 9	June 20	73	11,543	158.1
	2022	Swift	March 28	August 26	151	41,500	274.8
	2022	Swift	November 24	November 25	1	0	0
	2023	Swift	n/a	n/a	0	0	0
Hasler Bluffs	2020	SM2Bat+	April 15	April 26	11	5,446	495.1
	2021	Swift	April 9	May 11	33	14,938	452.7
	2022	Swift	March 30	July 16	108	51,428	476.2
	2022	Swift	October 6	December 31	69	445	6.4
	2023	Swift	January 1	April 29	110	3,929	35.7
Rainbow Rocks	2020	Swift	April 12	July 12	92	18,583	202.0
	2021	Swift	April 15	May 10	30	13,250	441.7
	2022	Swift	March 30	August 3	126	58,163	461.6
	2022	Swift	November 23	December 31	33	433	13.1
	2023	Swift	January 1	April 30	111	4,838	43.6
Tea Creek	2020	Swift	April 11	June 12	63	12,007	190.6
	2021	Swift	April 15	June 1	47	12,220	260.0
	2022	Swift	March 25	August 6	134	42,239	315.2
	2022	Swift	November 23	December 31	33	27	0.8
	2023	Swift	January 1	April 30	111	3,200	28.8

The dates that the first bat files were recorded by the sentinel site detectors in 2022 are presented in **Table 5-8**. The first bat call files at Bear Flats were recorded almost a month after detector installation in spring of 2022, while for other detectors, the first bat call files were recorded within two nights of the date the detector was installed. Big brown bats were the earliest species detected at all sites in spring 2022, although little brown myotis and unspecified Myotis as well as big brown bats were recorded at Bear Flats. Winter detections in 2023 began on January 1 or 2 with big brown bats recorded at all operating detectors.

Table 5-8 Dates of First Bat Files Recorded at Sentinel Sites in 2022

<table>
<tr><th>Site</th><th>Year</th><th>Date of File</th><th>Species</th><th>Comment</th></tr>
<tr><td rowspan="4">Bear Flats</td><td rowspan="3">2022</td><td rowspan="3">April 1</td><td>Big brown</td><td rowspan="3">Installed March 3</td></tr>
<tr><td>Little brown</td></tr>
<tr><td>Myotis</td></tr>
<tr><td>2023</td><td>January 1</td><td>Big brown</td><td>Operating January 1</td></tr>
<tr><td rowspan="2">Bergeron Cliffs</td><td>2022</td><td>March 30</td><td>Big brown</td><td>Installed March 28</td></tr>
<tr><td>2023</td><td>n/a</td><td>n/a</td><td>Detector failed</td></tr>
<tr><td rowspan="4">Hasler Bluffs</td><td rowspan="2">2022</td><td rowspan="2">March 30</td><td>Big brown</td><td rowspan="2">Installed March 30</td></tr>
<tr><td>Myotis</td></tr>
<tr><td rowspan="2">2023</td><td rowspan="2">January 2</td><td>Big brown</td><td rowspan="2">Operating January 1</td></tr>
<tr><td>Big brown or Silver-haired</td></tr>
<tr><td rowspan="4">Rainbow Rocks</td><td rowspan="3">2022</td><td rowspan="3">March 30</td><td>Big brown</td><td rowspan="3">Installed March 30</td></tr>
<tr><td>Big brown or Silver-haired</td></tr>
<tr><td>Big brown or hoary</td></tr>
<tr><td>2023</td><td>January 2</td><td>Big brown</td><td>Operating January 1</td></tr>
<tr><td rowspan="2">Tea Creek</td><td>2022</td><td>March 25</td><td>Big brown</td><td>Installed March 25</td></tr>
<tr><td>2023</td><td>January 2</td><td>Big brown</td><td>Operating January 1</td></tr>
</table>

A summary of the numbers of bat call files recorded at the sentinel sites in 2023 is presented in **Appendix B**. The identification assigned to the largest number of files (10,740) was big brown bat. Eastern red bat, silver-haired bat, hoary bat, little brown myotis, long-eared myotis, northern myotis, and long-legged myotis were also confirmed.

6.0 Conclusions

Based on the acoustic detections of *Myotis* and big brown bat files during 2022-2023 (**Table 5-5**), bats continue to actively use habitat at Portage Mountain. Bats continue to use two of the three roosts being monitored, with an average of 26 individuals observed per night during three emergence surveys at roost 9427G during the early maternity period. The 2023 counts represent the second highest numbers of bats counted at this roost during the early maternity period since 2018, when an average of 41 bats was observed over two counts (Hemmera 2022). The average number of bats counted generally dropped during 2020 and 2021, and then increased again in 2022 and 2023, except for late surveys in 2023 at 9427G. The late counts in 2023 were done at the end of July, later than counts done in previous years, which were done around mid-July. The lower number of bats during the later survey dates in 2023 suggests that by this time, bats may have already begun dispersing to cooler roosts or locations nearer to their hibernation sites, indicating a seasonal shift in bat activity and distribution patterns. Such a shift could indicate broader ecological or climatic changes affecting the bats' behaviour and distribution. It underscores the adaptability of bat populations to environmental variables, including temperature fluctuations and the availability of suitable roosting sites. Additionally, this pattern might signal changes in the bats' life cycle events, such as mating or foraging behaviours, in response to these environmental and physiological shifts. For instance, females do not require warm roosting sites once their pups can fly and forage for themselves.

Bat activity based on passive bioacoustics monitoring was similar to the 2021-2022 season. Although the total number of files per species group was higher in 2021-2022, the 2022-2023 season had a shorter monitoring period with almost 400 less active detector nights. The comparability of detections per active detector nights over the years strongly suggests that bats are still actively using Portage Mountain habitat.

The Portage Mountain acoustic detectors have recorded bats in the *Myotis* genus, including the endangered little brown and Northern myotis at the highest frequency from 2021 to 2023. The big brown & silver-haired bat species group has been detected at the second highest frequency from 2021 to 2023 as well. In contrast, big brown bat species is the most commonly detected species at the sentinel sites.

The sentinel site study design differs from the design at Portage Mountain. Sentinel site data were collected from five detectors spaced relatively far apart (e.g., > 5 km), and therefore each site has different environmental characteristics that are likely to influence bat activity. In comparison, all the Portage Mountain detectors are relatively close together (e.g., < 1.5 km). It may be important to consider site characteristics for each sentinel site detector and understand how this could affect bat activity at sentinel sites relative to Portage Mountain. Additionally, there are differences in sampling duration between the first years of sentinel site data collection and Portage Mountain data collection.

Reclamation of the Portage Mountain quarry is being planned. Reclamation will include the experimental creation of rock crevice features intended to function as bat roosting and hibernating habitat.

7.0 Closure

We sincerely appreciate the opportunity to have assisted you with this project and if there are any questions, please do not hesitate to contact the undersigned by phone at 604.669.0424.

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Appendix A

Acoustic Characteristics Used to Identify Bat Species

Table A-1 Text description of call characteristics of bat species in the study area, modified from Lausen, C. 2017. Bat data analysis cheatsheet. Unpubl.

Common Name	Scientific Name (Species Code)	Description*
Big brown bat / silver-haired bat	*Eptesicus fuscus / Lasionycteris noctivagans* (EPFU/LANO)	Calls are very similar. Diagnostic features include: LANO produces flat calls at 25 kHz, which EPFU does not; EPFU tends towards higher frequencies in clutter seen as an Fmax that can start above 60 kHz, whereas even with higher clutter calls (call duration < 6 ms), LANO tends towards Fmax values <50 kHz. The presence of second harmonic can aid in making differentiation because an Fmax <50 kHz can be attributed to species differences rather than distance of bat from microphone.
Eastern red bat	*Lasiurus borealis* (LABO)	Can have a low Sc <45 in open environments. Fmin ranges from 35 – 45 kHz and calls often have a characteristic "upturn" to the toe. MYLU in open environments can produce calls with very low Sc values also, so in an uncluttered situation, differentiating LABO and MYLU should be done using more than just call parameters. MYLU will generally have a more pronounced "elbow" or bend to its call (like a hockey stick shape) that you do not see in LABO (which instead is a smoothly curving call) Also, LABO, being a lasiurine, will tend to have an undulating up/down call pattern
Hoary bat	*Lasiurus cinereus* (LACI)	Long passes containing numerous pulses will be needed to differentiate this species from other low-frequency bats unless the calls are obviously <20 kHz with long duration (>10 ms) and TBC* (>400 ms). When call Fmin is >20 kHz, the duration and TBC is substantially less, but there will generally be an "up and down Fmin pattern" which characterizes this species
Long-eared myotis	*Myotis evotis* (MYEV)	Calls are generally steep (Sc>250+ but as low as 150 in some cases), with Fmin varying from 30 kHz up to 40. Can overlap with northern *Myotis* at its highest Fmin (~39 - 42 kHz). At higher frequencies where MYEV and MYSE can overlap, these passes should be placed into a general "long-eared" category. EPFU/ LANO can produce calls around 25 kHz that are steep, so there is possibility of overlapping with this species group, however, their Sc+ values are usually <150, whereas long-eared calls are steeper than this
Northern myotis	*Myotis septentrionalis* (MYSE)	Calls are generally steep, but unlike some of the other long-eareds, their call body slopes are more often low (as low as 150 OPS). Individual calls are generally Fmin 38-48 kHz. Below 43 kHz, MYSE overlaps with MYEV and would thus be grouped within the "Long-eared" category.
Little brown myotis	*Myotis lucifugus* (MYLU)	Often included in a more general "*Myotis*" or "High-frequency" category as MYLU calls resemble those of other *Myotis* species. Generally, MYLU echolocates with Fmin 32-45 kHz with a highly variable slope (Sc can be as low as 20 OPS in extremely uncluttered situations, but higher than 400 OPS in a cluttered situation such as interacting with another bat or encountering vegetation). In low clutter, the low slope of MYLU generally allows it to be discerned from other *Myotis*; a pronounced bend (elbow) in the pulse may be seen in low clutter, and this feature is typically not present in other 40 kHz *Myotis*. MYLU is widespread across Canada and is versatile in its echolocation, such that variation is immense.
Long-legged myotis	*Myotis volans* (MYVO)	Similar call to that of MYLU. Include in a more general "*Myotis*" or "High-frequency" category.

Note: * Fmin = minimum frequency, ms=milliseconds, OPS = octaves per second, Sc = Slope of the call, TBC = time between calls

Sources Nagorsen and Paterson (2012), Weller et al. (1998).

Table A-2 Acoustic Characteristics of Bat Species in the Study Area (modified from Lausen 2016 with input from Hansen, I-J [pers. comm. 2018])

Species Group*						Common Name	Acoustic Parameters									
Little Brown Myotis / Eastern Red Bat	*Myotis* Species	Big Brown / Silver-haired Bat	High-frequency Bat	Bats with Minimum Frequency 30 kHz	Low-frequency Bat	Species	Duration (milliseconds)		Maximum Frequency (kHz)		Minimum Frequency (kHz)		Characteristic Frequency (kHz)		Slope of Call Body (Octaves per second)	
							Avg**.	Range of Averages	Avg.	Range of Averages	Avg.	Range of Averages	Avg.	Range of Averages	Avg.	Range of Averages
						Hoary bat	9.5	7.2–3.5	34	24–42	21	18 - 23	22	20 - 24	29	13 - 57.5
						Silver-haired bat	7.3	4.9–12.1	37	28–49	25.5	23–27	27	25–28	36.5	11–73.5
						Big brown bat	7	3.3–13.3	41	26–62	25.5	21–31	27	21–32	48	12–135
						Long-eared myotis	4.1	1.4–2.4	64	49–88	34	29–41	42.8	34.5–66.6	343	158–855
						Long-legged myotis	3.2	1.7–6.3	68	56–85	41	36–45	47	39–63	202	64–503
						Eastern red bat	6.5	5–8	53	49–59	41	37–45	41	37–45	29	23–41
						Little brown myotis	3.5	1.6–6.7	76.5	49–91	42	32–47	48	38–57	175	63–464
						Northern myotis	1.9	1.0–2.7	71.5	51–81	42	38.5–44	51	45–57	354	211–484

*Grey cell = Bat categories are assigned to groups of bats based on the frequency (kHz) of their calls

**Avg. = average

Appendix B

Summary of Bat Files Recorded at Sentinel Sites

Table B-1 Numbers of Files and (Numbers of Files per Detector-night) Recorded at Sentinel Sites by Species in Spring and Winter 2022 and Winter 2023

Year	Sentinel Site Name					
	Bear Flats	Bergeron Cliffs	Hasler Bluffs	Rainbow Rocks	Tea Creek	Grand Total
Big brown bat						
2022	26980 (134.9)	8120 (53.8)	3045 (17.2)	8265 (52.0)	16202 (97.0)	62612 (73.3)
2023	5276 (47.5)	0	1042 (9.5)	2569 (23.1)	1853 (16.7)	10740 (24.2)
Big brown bat or hoary bat						
2022	1973	1426	289	981	1434	6103
2023	2	0	0	0	1	3
Big brown bat or silver-haired bat						
total						
2022	6206	2275	4838	2269	2951	18539
2023	2660	0	636	807	1022	5125
Big brown bat or long-eared myotis						
2022	39	11	4	19	50	123
2023	64	0	0	3	22	89
Eastern red bat						
2022	19	55	0	27	4	105
2023	0	0	1	0	0	1
Eastern red bat or little brown myotis						
2022	50	3	1	319	354	727
2023	2	0	0	0	0	2
Hoary bat						
2022	1911	1217	32	108	1489	4757
2023	3	0	0	0	0	3
Silver-haired bat						
2022	868	973	176	328	2762	5107
2023	56	0	37	0	240	333
Long-eared myotis						
2022	550	590	243	1960	215	3558
2023	232	0	5	2	12	251
Little brown myotis						
2022	6402	10905	2568	11769	6188	37832
2023	138	0	60	163	32	393

Year	Sentinel Site Name					
	Bear Flats	Bergeron Cliffs	Hasler Bluffs	Rainbow Rocks	Tea Creek	Grand Total
Little brown myotis or long-legged myotis						
2022	2	0	0	0	0	2
2023	0	0	0	0	0	0
Myotis						
2022	4949	11451	17325	17019	7574	58318
2023	185	0	1563	740	15	2503
Northern myotis						
2022	63	164	193	138	43	601
2023	0	0	19	7	0	26
Long-legged myotis						
2022	1315	4310	23159	15394	3000	47178
2023	9		566	547	3	1125

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Appendix 9. Bat Box Mitigation Structures Monitoring 2023 Annual Report

DRAFT

REPORT

Site C Mitigation Structures

2023 Bat Box Monitoring Summary

Submitted to:

BC Hydro

Attention: Brent Matsuda
333 Dunsmuir St, 13th floor
Vancouver, BC V6B 5R3

Submitted by:

WSP Canada Inc.

10803 91st Ave Unit A Fort St John, BC V1J 6L3 Canada

+1 250 785 9281

CA0006012.0622-002-R-RevA

Distribution List

e-copy: BC Hydro

e-copy: WSP Canada Inc.

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APPENDICES

1.0 OVERVIEW

The broad mitigation objectives of BC Hydro's bat roost box program are to mitigate the effects of the unavoidable loss of summer roosting habitat for tree roosting bats as a result of construction of the Site Clean Energy Project (The Project). BC Hydro contracted Blueberry River Enterprises (BRE) for the installation and monitoring of 121 bat roost structures at 20 sites (Figure 1). Bat boxes associated with the program were installed between 2018 and 2020. Golder Associates Ltd. [formerly Golder and now WSP Canada Inc. (WSP)] were contracted by BRE to provide Bat ecological technical expertise in support of the installation and box monitoring program, and to lead monitoring field work in conjunction with Blueberry River First Nation (BRFN) representatives. Boxes were monitored during the summer of 2019 (Golder 2020), 2020 (Goler 2021a), 2021 (Golder 2022), 2022 (WSP 2023), to assess occupancy by bats within installed bat boxes.

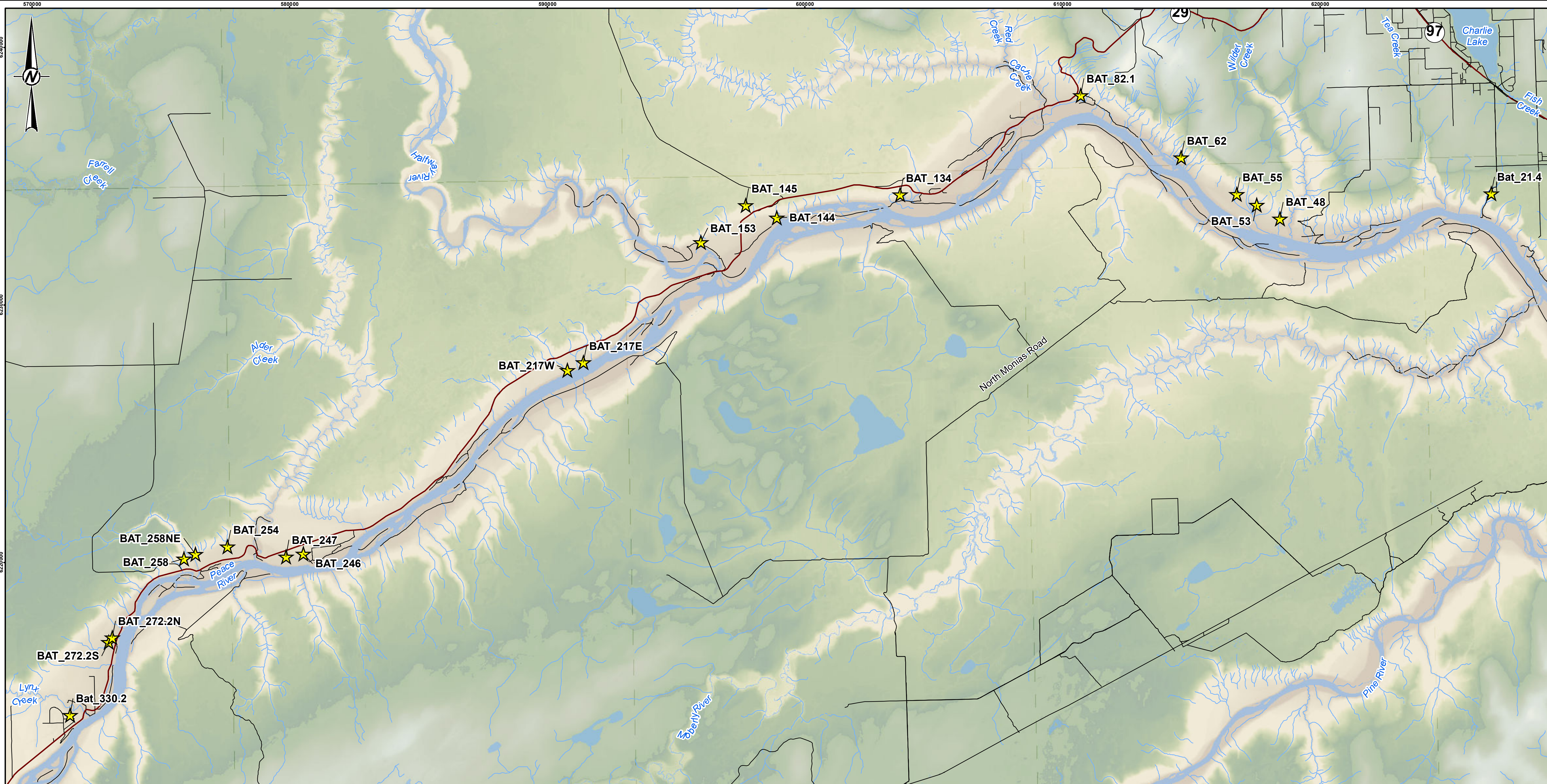
BC Hydro contracted WSP to continue monitoring to assess occupancy by bats within previously installed boxes in 2023 (see BC Hydro Outline Agreement #4600001896). This report documents the results of bat box monitoring activities undertaken by WSP with assistance from Blueberry River First Nation representatives in 2023.

2.0 BAT BOX BACKGROUND INFORMATION

The following details relating to installed bat roost structures are summarized from Golder's 2021 installation report (Golder 2021b) to provide background context and describe the configuration of installed bat roost boxes. The locations of bat boxes installed from 2018 through 2021 are shown in Figure 1 and the location coordinates and bat box type for each location are summarized in Table 1.

In the fall of 2018 and 2019, 114 bat roost boxes were installed, comprised of two Rocket boxes and four Maternity boxes at each of 19 sites along the north shore of the future Site C reservoir (Figure 1). Four Maternity boxes, a Rocket box and the Bat Condo were installed at another site in June 2020, bringing the total number of roost structures to 120: 39 Rocket boxes, 80 Maternity boxes and one Bat Condo. An additional Maternity box was installed in winter 2020/2021 to complete the specified number of boxes in the installation program.

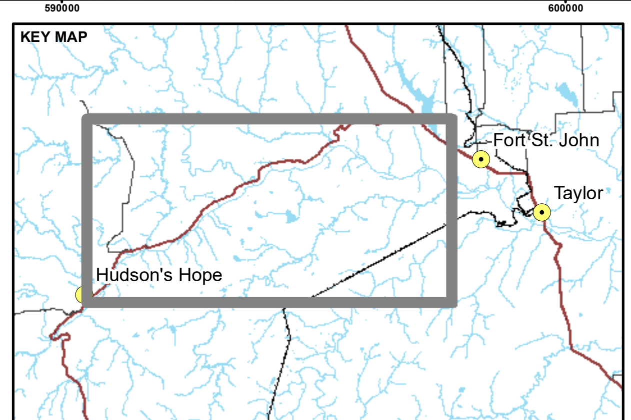
Bat roost boxes were designed and constructed following diagrams from Bat Conservation International (Tuttle, Kiser, and Kiser 2004), and the Pennsylvania Game Commission (Butchkoski and Hassinger 1997), as per design drawings listed in Contract #605654. Two types of bat roost boxes were constructed by BRE, Rocket boxes and Maternity boxes (See Photos 1-3, Appendix A). Rocket boxes have dimensions of 24.3 cm by 24.3 cm by 91.4 cm tall, with a 25.4 cm by 25.4 cm roof. Maternity boxes have dimensions of 44.5 cm by 10.5 cm by 78.7 cm tall, with a 16.5 cm by 48 cm roof. Rocket and Maternity boxes were assembled by BRE, painted light brown, dark brown, or light grey, and mounted on steel poles. Each pole was mounted with either a single Rocket box or two Maternity boxes. A third type of bat structure, a Bat Condo, was constructed and provided by BC Hydro using the design drawings listed in the Contract # 605654 for installation by BRE (See Photos 4 and 10, Appendix A). The bat condo has dimensions of 243.8 cm by 243.8 cm by 259.1 cm tall.



LEGEND

- ★ BAT BOX SITE
- HIGHWAY
- ROAD
- WATERCOURSE
- WATERBODY

KEY MAP



0 3,000 6,000

1:150,000 METRES

REFERENCE(S)

1. PRELIMINARY STABILITY IMPACT LINES AND GENERAL CLEARING AREAS OBTAINED FROM BC HYDRO.
2. TRANSPORTATION FEATURES OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. FISHER TYPE 1 DENNING STAND AND WATER BASE DATA OBTAINED FROM THE PROVINCE OF BRITISH COLUMBIA.

DATUM: NAD83 PROJECTION: UTM ZONE 10N

CLIENT
BC HYDRO

PROJECT
SITE C WILDLIFE MITIGATION MONITORING PROGRAM

CONSULTANT

wsp

YYYY-MM-DD	2023-12-20
DESIGNED	RJ
PREPARED	JP
REVIEWED	MF
APPROVED	IJ

TITLE
SITE C MITIGATION BAT BOX SITES

PROJECT NO.	CONTROL	REV.	FIGURE
CA0006012.0622	2000	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Table 1: Bat Box Details

Site ID	Installation Date	Box	Easting/Northing	Box Type	Orientation	Colour	Height (cm)
BAT_21.4	14-Nov-18	A/B	626656 / 6234337	Maternity	N	Dark	316
					S		
		C/D	626655 / 6234340	Maternity	NW	Light	310
					SE		
		E	626656 / 6234302	Rocket	N/A	Dark	292
		F	626636 / 6234306	Rocket	N/A	Light	293
BAT_48	6-Nov-19	A/B	618467 / 6233354	Maternity	S	Light	310
					N		
		C/D	618458 / 6233239	Maternity	S	Dark	294
					N		
		E	618452 / 6233358	Rocket	N/A	Light	272
		F	618510 / 6233211	Rocket	N/A	Light	292
BAT_53	6-Nov-19	A/B	617531 / 6233892	Maternity	S	Dark	275
					N		
		C/D	617497 / 6233917	Maternity	S	Light	272
					N		
		E	617483 / 6233926	Rocket	N/A	Light	260
		F	617542 / 6233890	Rocket	N/A	Light	292
BAT_55	5-Nov-19	A/B	616779 / 6234307	Maternity	S	Light	294
					N		
		C/D	616787 / 6234304	Maternity	S	Light	270
					N		
		E	616765 / 6234308	Rocket	N/A	Light	273
		F	616801 / 6234302	Rocket	N/A	Light	273
BAT_62	5-Nov-19	A/B	614618 / 6235727	Maternity	SE	Dark	302
					NW		
		C/D	614635 / 6235720	Maternity	S	Light	284
					N		
		E	614625 / 6235722	Rocket	N/A	Dark	253
		F	614630 / 6235721	Rocket	N/A	Dark	281

Site ID	Installation Date	Box	Easting/Northing	Box Type	Orientation	Colour	Height (cm)
BAT_82.1	17-Oct-19	A/B	610712 / 6238149	Maternity	S	Light	303
					N		
		C/D	610717 / 6238147	Maternity	S	Dark	286
					N		
		E	610709 / 6238151	Rocket	N/A	Dark	262
		F	610720 / 6238145	Rocket	N/A	Light	264
BAT_134	15-Nov-18	A/B	603697 / 6234289	Maternity	NW	Light	345
					SE		
		C/D	603710 / 6234305	Maternity	N	Dark	355
					S		
		E	603884 / 6234389	Rocket	N/A	Light	355
		F	603721 / 6234321	Rocket	N/A	Dark	330
BAT_144	8-Oct-19	A/B	598905 / 6233396	Maternity	S	Light	296
					N		
		C/D	598909 / 6233398	Maternity	S	Dark	286
					N		
		E	598914 / 6233399	Rocket	N/A	Dark	264
		F	598918 / 6233400	Rocket	N/A	Light	290
BAT_145	2-Oct-19	A/B	297697 / 6233881	Maternity	SE	Dark	326
					NW		
		C/D	598146 / 6233897	Maternity	SE	Light	289
					NW		
		E	597703 / 6233886	Rocket	N/A	Light	272
		F	598148 / 6233891	Rocket	N/A	Dark	275
	19-Feb-21	G	598090 / 6233874	Maternity	S	Dark	274 (~240 from deck)
BAT_153	9-Nov-18	A/B	595956 / 6232445	Maternity	NW	Light	367
					SE		
		C/D	595961 / 6232449	Maternity	NW	Light	340
					SE		
		E	595983 / 6232465	Rocket	N/A	Light	297
		F	595985 / 6232466	Rocket	N/A	Dark	307

Site ID	Installation Date	Box	Easting/Northing	Box Type	Orientation	Colour	Height (cm)
BAT_217	16-Oct-19	A/B	591400 / 6227774	Maternity	S	Dark	293
					N		
		C/D	591385 / 6227769	Maternity	SE	Dark	293
					NW		
		E	591393 / 6227772	Rocket	N/A	Light	281
		F	591388 / 6227768	Rocket	N/A	Light	273
BAT_217W	16-Oct-19	A/B	590778 / 6227474	Maternity	S	Light	290
					N		
		C/D	590775 / 6227472	Maternity	S	Dark	290
					N		
		E	590775 / 6227454	Rocket	N/A	Light	292
		F	590765 / 6227469	Rocket	N/A	Light	284
BAT_246	8-Nov-18	A/B	580526 / 6220350	Maternity	N	Light	340
					S		
		C/D	580533 / 6220350	Maternity	NE	Dark	310
					SW		
		E	580539 / 6220350	Rocket	N/A	Light	307
		F	580545 / 6220351	Rocket	N/A	Dark	300
BAT_247	8-Nov-18	A/B	579850 / 6220237	Maternity	NW	Dark	320
					SE		
		C/D	579877 / 6220239	Maternity	NW	Light	323
					SE		
		E	579859 / 6220238	Rocket	N/A	Dark	284
		F	579866 / 6220239	Rocket	N/A	Light	317
BAT_254	31-Oct-18	A/B	577577 / 6220628	Maternity	N	Dark	328
					S		
		C/D	577587 / 6220633	Maternity	NW	Very Light	327
					SE		
		E	577583 / 6220628	Rocket	N/A	Light	312
		F	577592 / 6220635	Rocket	N/A	Dark	305
BAT_258	25-Oct-18	A/B	575892 / 6220158	Maternity	NW	Dark	315
					SE		
		C/D	575909 / 6220174	Maternity	N	Dark	310
					S		
		E	575909 / 6220168	Rocket	N/A	Dark	272

Site ID	Installation Date	Box	Easting/Northing	Box Type	Orientation	Colour	Height (cm)
		F	575904 / 6220165	Rocket	N/A	Dark	274
BAT_258NE	26-Oct-18	A/B	576331 / 6220336	Maternity	N	Dark	303
					S		
		C/D	576333 / 6220339	Maternity	SE	Dark	320
					NW		
		E	576330 / 6220334	Rocket	N/A	Dark	292
		F	576335 / 6220341	Rocket	N/A	Dark	294
BAT_272.2N	7-Nov-18	A/B	573108 / 6217095	Maternity	NW	Dark	306
					SE		
		C/D	573104 / 6217098	Maternity	N	Light	310
					S		
		E	573107 / 6217091	Rocket	N/A	Light	306
		F	573110 / 6217103	Rocket	N/A	Dark	277
BAT_272.2S	7-Nov-18	A/B	572969 / 6216914	Maternity	N	Light	342
					S		
		C/D	572977 / 6216925	Maternity	NW	Dark	328
					SE		
		E	572971 / 6216918	Rocket	N/A	Dark	340
		F	572972 / 6216924	Rocket	N/A	Dark	307
BAT_330.2	3-June-20	A/B	571463 / 6214122	Maternity	S	Dark	325
					N		
		C/D	571476 / 6214117	Maternity	SE	Light	341
					NW		
		E	571472 / 6214122	Rocket	N/A	Dark	318
	11-June-20	Condo	571462 / 6214112	Condo	N/A	Dark	305

3.0 MONITORING SUMMARY

The following monitoring activities were conducted at installed bat boxes in 2023:

- assessment of condition of each of the installed boxes and guano screens;
- three occupancy surveys were conducted at most bat roost structures with the exception of sites accessed via Old Hope Road where one occupancy survey was conducted due to access restrictions in June and July;
- one evening emergence count at a subset of five bat box sites; and
- installation of temperature loggers within a subset of roost structures and collection of associated data.

The following subsections provide summaries of the required monitoring activities discussed above and related results.

3.1 Occupancy Surveys

Bat boxes were examined for evidence of occupancy by monitoring installed screens below boxes for the presence of bat guano, and by visual observation of bats in the structure and species identification where possible (data summary presented in Table 2; Photos in Appendix A). Occupancy surveys were conducted by one WSP biologist and one BRFN technician in June, July, and September as summarized below and in Table 2 (see Subsection 3.2):

- 6-9 June 2023: Guano was observed beneath 80 boxes (53 Maternity boxes, 26 Rocket boxes, and the Bat Condo) at 16 sites (BAT_21.4, 82.1, 134, 144, 145, 153, 217E, 217W, 246, 247, 254, 258NE, 258, 272.2N, 272.2S, and 330.2), representing an occupancy rate of 82.5% of surveyed boxes (97) and 100% of surveyed sites (16). Bats were visually observed in 33 boxes (25 Maternity and 8 Rocket) at 9 sites (BAT_21.4, 134, 145, 153, 258, 258NE, 272.2N, 272.2S, and 330.2). Additionally, bats were audibly observed within two boxes (Rocket) at 272.2N. Access through a private property off of Old Hope Road was not available in June and as such four sites were not surveyed during this period (BAT_48, 53, 55, and 62).
- 13-16 July 2023: Guano was observed beneath 86 boxes (59 Maternity boxes, 26 Rocket boxes, and the Bat Condo) at 15 different sites (BAT_21.4, 82.1, 134, 144, 145, 153, 217E, 217W, 246, 254, 258, 258NE, 272.2N, 272.2S, and 330.2), representing an occupancy rate of 88.7% of surveyed boxes (97) and 93.8% of surveyed sites (16). Bats were visually observed in 41 boxes (29 Maternity and 12 Rocket) at 13 sites (BAT_21.4, 82.1, 134, 145, 153, 217E, 217W, 247, 258, 258NE, 272.2N, 272.2S, and 330.2). Additionally, bats were audibly observed within two boxes (Rocket) at 82.1 and 272.2N. Access through a private property off of Old Hope Road was not available in July and as such four sites were not surveyed during this period (BAT_48, 53, 55, and 62).
- 27-29 September 2023: Guano was observed beneath 91 boxes (63 Maternity boxes, 27 Rocket boxes, and the Bat Condo) from 18 sites, representing an occupancy rate of 79.1% of surveyed boxes (115) and 94.7% of surveyed sites (19). Bats were not observed (visually or audibly) at any site. Access to the Wilder Creek sites (BAT_48, 53, 55, and 62) was gained via Bennett Road, but access to BAT_62 was not possible due to muddy road conditions.

In 2023, the number of occupied boxes increased between spring and summer monitoring periods, to a total of 86 in July (Figure 2; Table 2). A greater number of boxes were found to be occupied during spring and fall monitoring visits in 2023 relative to 2022 (Appendix C; Golder 2023). Since the total number of boxes installed has varied from year to year (60 in 2019, 97 in July 2020, 120 in September 2020, and 121 in 2021/2022/2023), and the total number of boxes surveyed has varied (all available surveyed in 2019/2020/2021, 97 surveyed in September 2022, June and July 2023, 115 surveyed in September 2023), the rate of occupation is also reported below for comparison. The inter-annual rate of occupation shows a general increase with time until 2023, when only the September survey resulted in a lower occupancy rate (Figure 3; Table 2). Although the spring 2023 survey identifies an increase in occupation when compared to previous years, this survey occurred 1 month (June rather than May) later than previous years spring surveys, likely resulting in increased occupation estimates. Together these results may indicate that occupancy rates are beginning to plateau and local bats are familiar with the installed boxes. Factors other than familiarity will also affect box use, such as weather variations, overwintering survival, and maternity success.

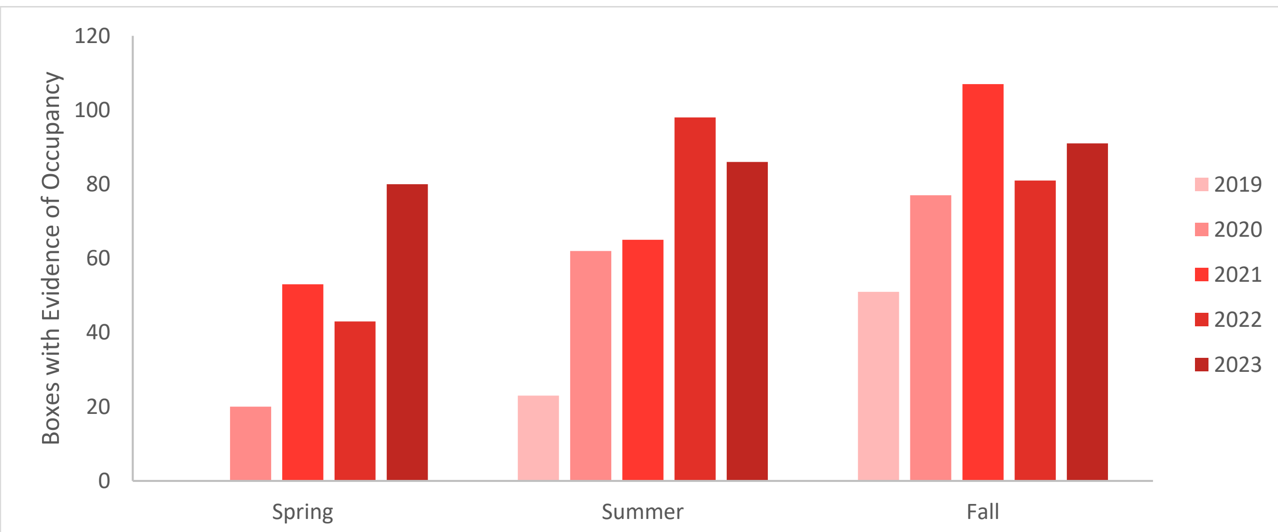


Figure 2: Total number of boxes with evidence of occupancy observed during all monitoring survey years. Sixty boxes were present in 2019, 120 boxes were present by September 2020, and 121 boxes were present in 2021/2022/2023. Some installed boxes were not surveyed each season due to access constraints (Appendix C). In 2023, spring surveys occurred in June rather than May.

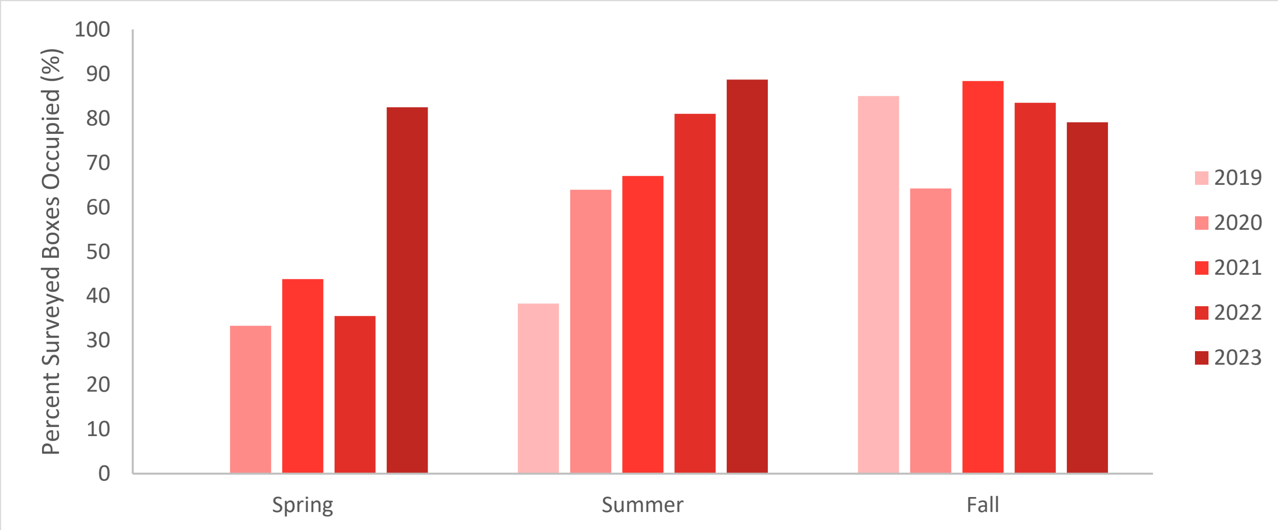


Figure 3: Percent of installed and surveyed boxes with evidence of occupancy observed during all monitoring survey years. In 2023, spring surveys occurred in June rather than May.

While observed guano quantity cannot be used to accurately determine the number of bats present, it is an appropriate proxy to estimate general classes of colony size (Kunz and Reynolds 2003). Guano quantity was scored as ‘Small’, ‘Moderate’, or ‘Large’ to provide an estimate of bat box use. A ‘Small’ quantity consisted of < ~15 individual pieces of guano, indicative of infrequent box use by a small number of bats. A ‘Moderate’ quantity consisted of ~15 to < ~100 individual pieces of guano, indicative of relatively frequent use by a small number of bats, or infrequent use by many bats. A ‘Large’ quantity consisted of > ~100 pieces of guano, indicative of frequent use by many bats. Individual pieces of guano were rarely counted, and so score categories were estimated in the field (see Appendix A, photos 11-14 for examples).

Where guano was present, observed quantities were generally consistent with those observed in 2019, 2020, 2021, and 2022 (Appendix C; Golder 2020, Golder 2021a, Golder 2022). Of the 80 boxes with guano in June 2023, 50 (62.5 %) had a ‘Small’ amount, ten (12.5 %) had a ‘Moderate’ amount, and 20 (25.0 %) had a ‘Large’ amount (Figure 4). Of the 86 boxes with guano in July, 36 (41.9 %) had a ‘Small’ amount, 22 (25.6 %) had a ‘Moderate’ amount, and 28 (32.5 %) had a ‘Large’ quantity. Of 91 boxes with guano observed in September, 42 (46.1 %) had a ‘Small’ amount, 20 (22.0 %) had a ‘Moderate’ amount, and 29 (31.9 %) had a ‘Large’ amount. These results follow expected activity levels with greater guano accumulations occurring during the months when the warmest weather is expected. The September increase in the number of sites with a small amount of guano may be related to the breakup and dispersal of individuals from maternity sites.

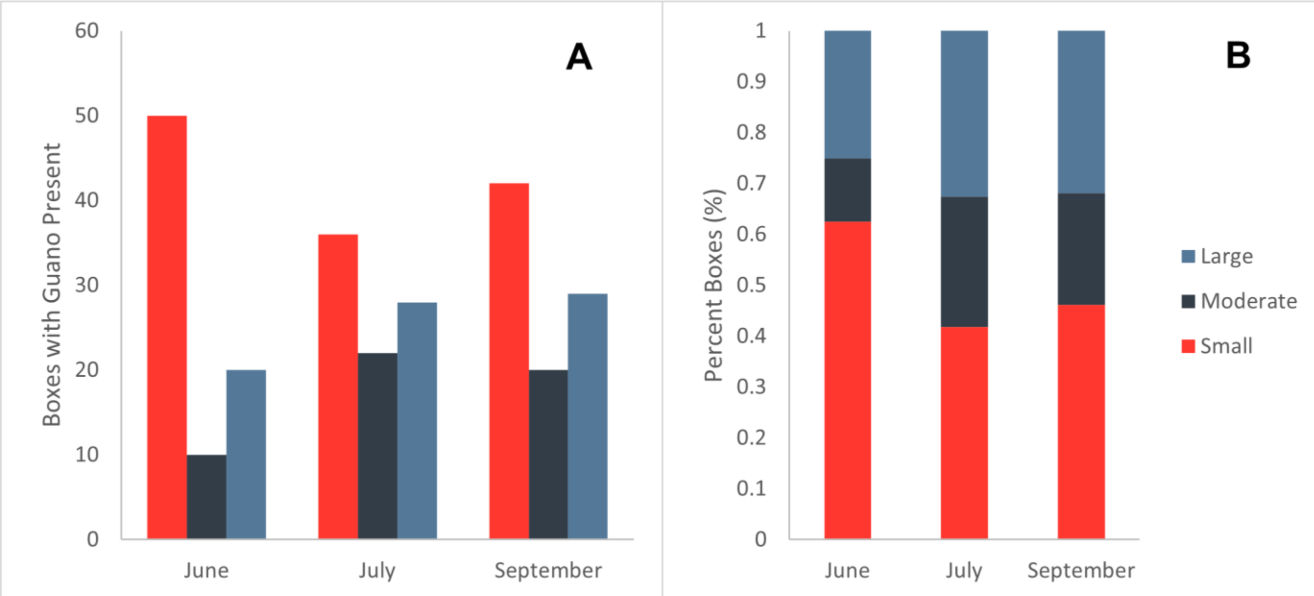


Figure 4: A) Number of bat boxes scored to have a 'Small', 'Moderate', or 'Large' quantity of guano in 2023, and B) proportion of boxes with guano scored as 'Small', 'Moderate', or 'Large' in 2023.

3.2 Emergence Counts

Emergence counts are specified to be completed at five sites per year after pups are volant, between June and the end of July. Emergence surveys were performed at five sites, which demonstrated evidence of occupancy, and the greatest number of individuals visually observed during the July occupancy survey. These were performed by one WSP biologist and one BRFN technician at each site who sat facing the boxes such that the boxes were silhouetted against the sky, allowing effective visual observation of emerging bats (Appendix A, photo 16). Surveys started shortly before sunset and ended about an hour afterwards. The emergence counts were performed at five sites on five evenings in July to determine the number of occupants present in each box on the day of the count (Table 2). Additionally, one ultrasonic recorder was deployed during the surveys to alert observers of bat activity and record bat calls (See Section 3.3).

- **BAT_272.2S:** Emergence counts were performed on 17 July 2023. Upon initial assessment of the boxes, approximately 15+ bats were observed within boxes A, B, C, and D, no bats were observed within boxes E or F, however they were audibly heard within the boxes. One dead pup was observed beneath box E. One ultrasonic recorder was set up prior to beginning the survey, in the center of the boxes. A total of 267 bats were observed emerging from boxes at this site: 124 from boxes C/D, 61 from boxes A/B, 51 from box E, and 31 from box F (Figure 5). Nine bats were observed within box D and six within box B following the completion of the survey.
- **BAT_258NE:** Emergence counts were performed on 18 July 2022. Upon initial assessment of the boxes, approximately 15+ bats were observed within box A, approximately seven bats were observed within box C, six were observed within box B, three within box E, and two within box D. One ultrasonic recorder was set up prior to beginning the survey, in the center of the boxes. A total of 129 bats were observed to have emerged: 65 from boxes A/B, 37 from box E, 16 from box F, and 11 from boxes C/D (Figure 6). Seven bats were observed within box A, and one within both boxes C and E following the completion of the survey.

- **BAT_272.2N:** Emergence counts were performed on 19 July 2023. Upon initial assessment of the boxes, approximately ten bats were observed within box A, nine within box C, seven within box B, and two within box D. No bats were observed within boxes E or F; however, they were audibly heard within the boxes. One ultrasonic recorder was set up prior to beginning the survey, in the center of the boxes. A total of 198 bats were observed to have emerged in total: 120 from box F, 43 from boxes A/B, 26 from boxes C/D, and nine from box E (Figure 7). Three bats were observed within box A following the completion of the survey.
- **BAT_153:** Emergence counts were performed on 20 July 2023. Upon initial assessment of the boxes, 20+ bats were observed in box A, seven bats were observed in box C, six within box F, and one within box D. One ultrasonic recorder was set up prior to beginning the survey, in the center of the boxes. A total of 172 bats were observed to have emerged in total: 102 from boxes A/B, 46 from box F, 21 from boxes C/D, and three from box E (Figure 8). Six bats were observed within box A following the completion of the survey.
- **BAT_145:** Emergence counts were performed on 21 July 2023. Due to the configuration of the boxes it was only possible to survey either boxes A/B and E, C/D and F, or G. Since more guano was present beneath boxes C/D and F, and a greater number of bats were directly observed within these boxes the week prior, they were selected to be monitored. Upon initial assessment of the boxes, 15+ bats were observed in boxes C and D, and five bats were observed in box F. One ultrasonic recorder was set up prior to beginning the survey, in the center of the boxes. A total of 167 bats were observed to have emerged: 87 from boxes C/D, and 80 from box F (Figure 9). Four bats were observed remaining in box F, three within box D, and one remained within box C following the completion of the survey.

No juvenile bats were identified in the roost boxes during emergence surveys, and so the sex and reproductive status of these bats is unknown. Regardless, the large groupings of bats present at BAT_145, 153, 258NE, 272.2N, and 272.2S suggest maternity activity likely occurred at these sites.

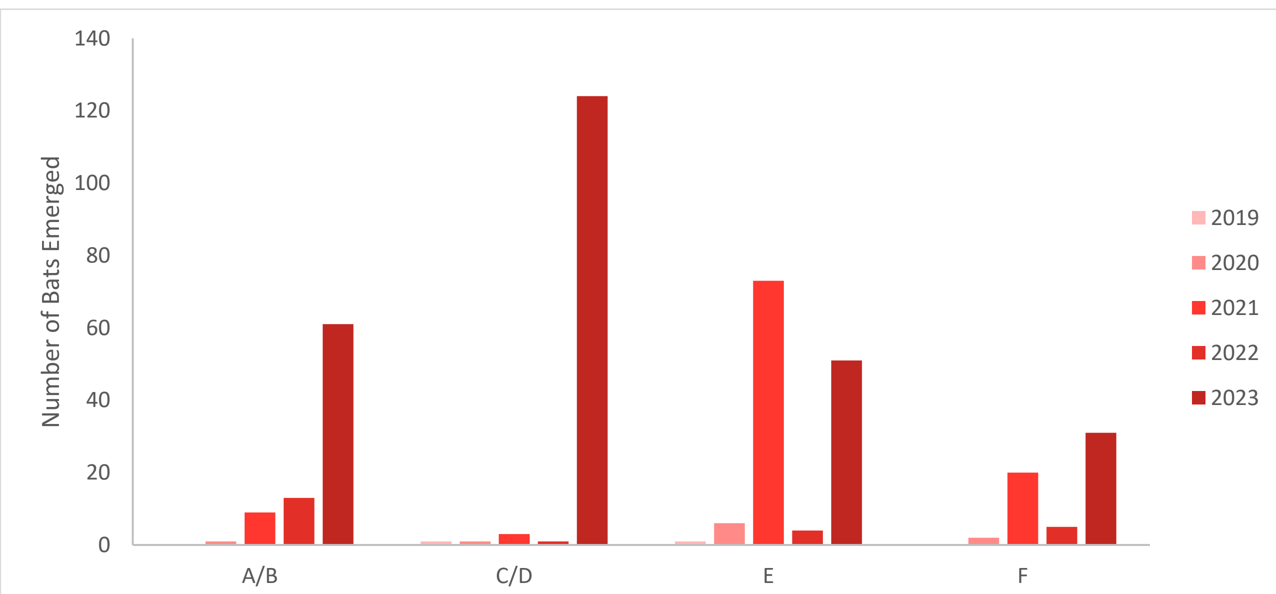


Figure 5: Number of bats counted emerging from each box at site BAT_272.2S in each of 2019, 2020, 2021, 2022, and 2023.

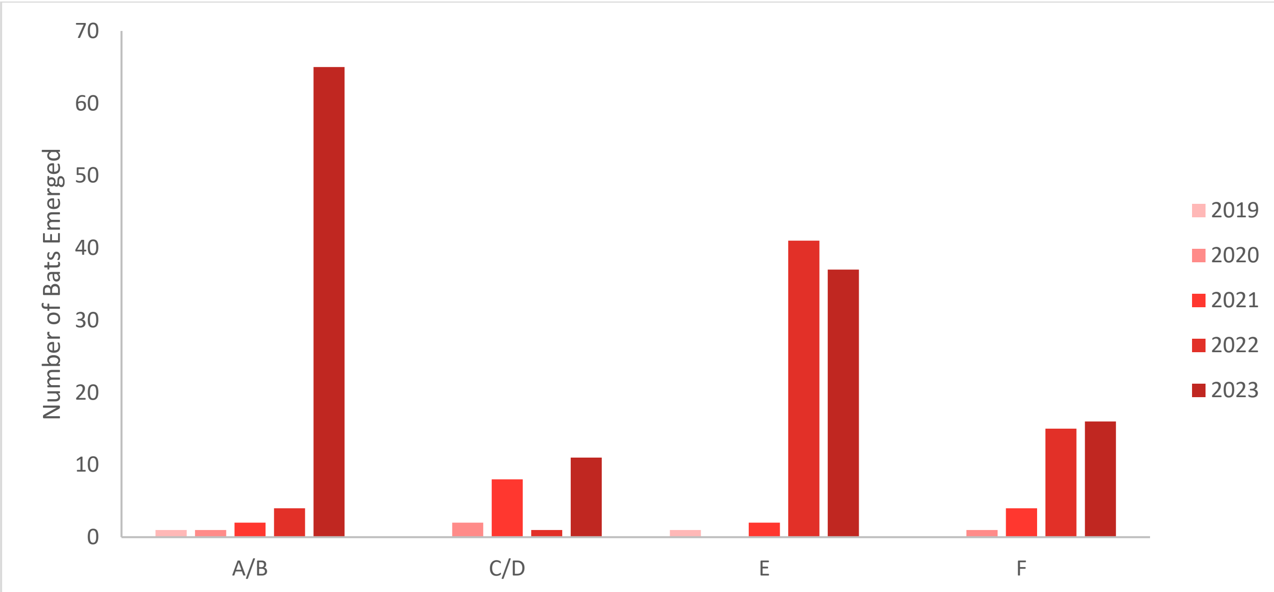


Figure 6: Number of bats counted emerging from each box at site BAT_258NE in each of 2019, 2020, 2021, 2022, and 2023.

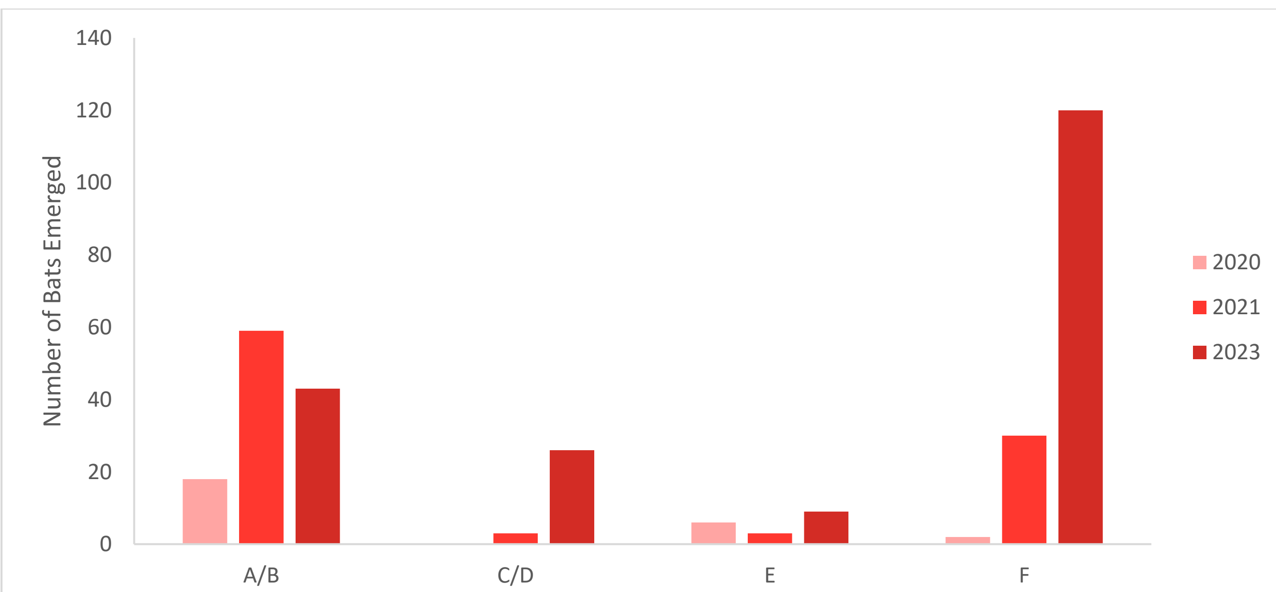


Figure 7: Number of bats counted emerging from each box at site BAT_272.2N in each of 2020, 2021, and 2023.

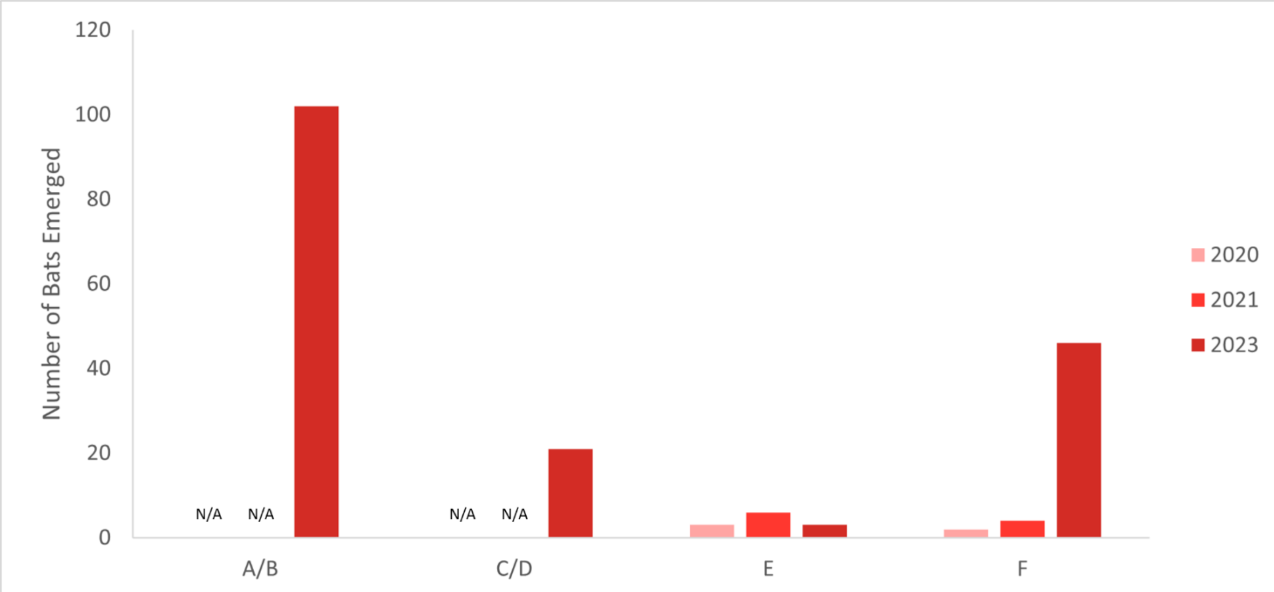


Figure 8: Number of bats counted emerging from each box at site BAT_153 in each of 2020, 2021, and 2023.

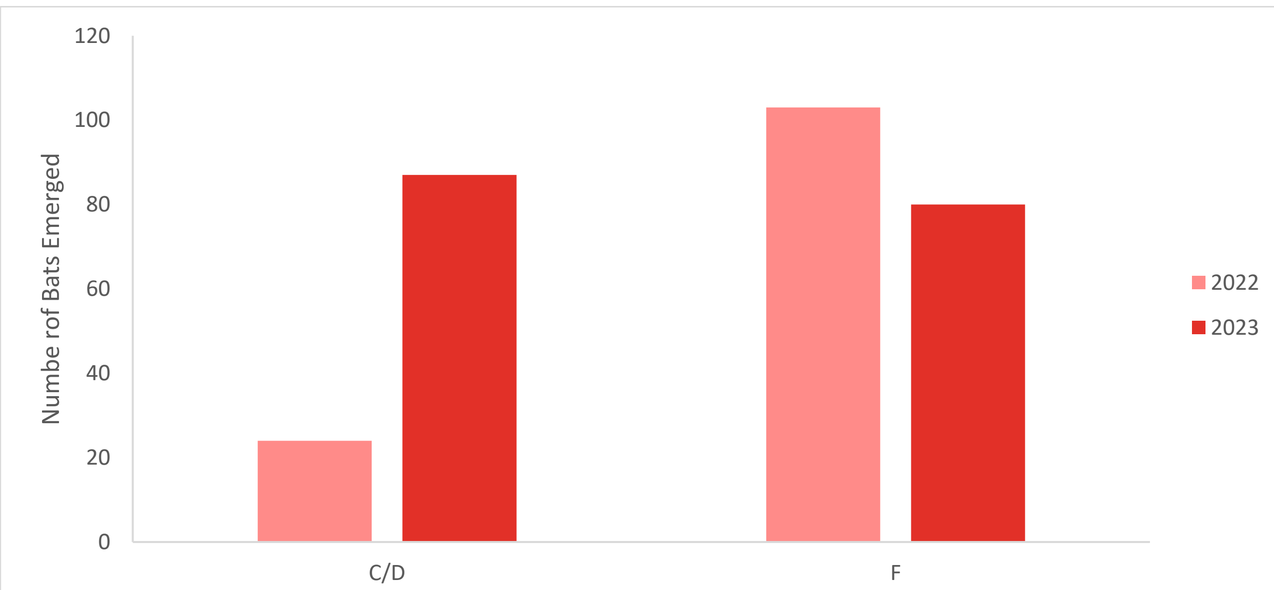


Figure 9: Number of bats counted emerging from each box at site BAT_145 in each of 2022 and 2023.

All of the emergence surveys completed in 2023 were performed at sites which had also been surveyed in at least one previous year, allowing for direct annual comparisons (Figures 5, 6, 7, 8, and 9). All sites saw increases in bat emergence when compared to any previous year they were surveyed. Interestingly, the box at each site with the highest abundance was variable from year to year and often switched between boxes of different types (e.g., BAT_258NE; E to A/B for 2022-2023).

In 2022, there was a noticeable decrease in emerging bats at BAT_272.2S (78.1% lower than 2021; Figure 5). However, the 2023 survey showed a large increase which exceeded any numbers seen in previous years. BAT_272.2N would have likely shown a similar pattern in 2022 had the emergence survey not been cancelled, with >40 bats observed during earlier occupancy checks and only 11 during the check prior to the emergence survey. Much like BAT_272.2S, bat abundance at 272.2N saw a larger increase in 2023 than any previous year (Figure 7). This suggests that the reduction in numbers from 2021 to 2022 was likely an artifact of survey timing (maternity colony disbursement) and not a change in the pattern of site use.

Table 2: Bat Occupancy and Emergence Survey Results

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			6-9 June	13-16 Jul	27-29 Sep,	17-21 July	
BAT_21.4	A/B	Maternity	G(S)	G(M)	G(M)	-	TL
	C/D	Maternity	G(S); VI(1)	G(M); VI(1)	G(M)	-	TL
	E	Rocket	G(S)	G(S)	G(S)	-	SD
	F	Rocket	None	G(S)	G(S)	-	TL
BAT_48	A/B	Maternity	Not visited	Not visited	G(S)	-	SR
	C/D	Maternity	Not visited	Not visited	None	-	SR
	E	Rocket	Not visited	Not visited	None	-	SR
	F	Rocket	Not visited	Not visited	None	-	SR
BAT_53	A/B	Maternity	Not visited	Not visited	G(S)	-	SR
	C/D	Maternity	Not visited	Not visited	None	-	SR
	E	Rocket	Not visited	Not visited	None	-	SR
	F	Rocket	Not visited	Not visited	None	-	SR
BAT_55	A/B	Maternity	Not visited	Not visited	None	-	SR
	C/D	Maternity	Not visited	Not visited	None	-	SR
	E	Rocket	Not visited	Not visited	None	-	SR
	F	Rocket	Not visited	Not visited	None	-	SR
BAT_62	A/B	Maternity	Not visited	Not visited	Not visited	-	-
	C/D	Maternity	Not visited	Not visited	Not visited	-	-
	E	Rocket	Not visited	Not visited	Not visited	-	-
	F	Rocket	Not visited	Not visited	Not visited	-	-
BAT_82.1	A/B	Maternity	G(M)	G(L); VI(2)	G(M)	-	-
	C/D	Maternity	G(M)	G(M)	G(S)	-	-
	E	Rocket	G(S)	G(M)	G(M)	-	Superficial paint damage
	F	Rocket	G(S)	G(M); AO	G(M)	-	-
BAT_134	A/B	Maternity	G(S); VI(1)	G(S)	None	-	SR
	C/D	Maternity	G(S); VI(1)	G(S); VI(1)	G(S)	-	SR

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			6-9 June	13-16 Jul	27-29 Sep,	17-21 July	
	E	Rocket	G(S)	G(S); VI(1)	G(S)	-	SR
	F	Rocket	G(S); VI(2)	G(M); VI(3)	G(S)	-	-
BAT_144	A/B	Maternity	G(S)	G(S)	G(M)	-	-
	C/D	Maternity	None	G(S)	G(M)	-	-
	E	Rocket	G(S)	G(M)	G(M)	-	-
	F	Rocket	G(S)	G(M)	G(L)	-	-
BAT_145	A/B	Maternity	G(S); VI(1)	G(S); VI(1)	G(S)	-	-
	C/D	Maternity	G(L); VI(>39)	G(L); VI(>43)	G(L)	VI(91)	-
	E	Rocket	G(M), VI(1)	G(M)	G(S)	-	-
	F	Rocket	G(L); VI(6)	G(L): VI(11)	G(L)	VI(84)	-
	G	Maternity	G(S); VI(1)	G(L); VI(14)	G(S)		-
BAT_153	A/B	Maternity	G(S); VI(3)	G(L); VI(>34); M(2)	G(L)	VI(108)	-
	C/D	Maternity	G(L); VI(>15)	G(M); VI(11)	G(L)	VI(21)	SR; TL
	E	Rocket	G(M)	G(L); VI(3)	G(L)	VI(3)	SR
	F	Rocket	G(L); VI(2)	G(L); VI(2)	G(L)	VI(46)	TL
BAT_217E	A/B	Maternity	G(S)	G(S); VI(1)	G(S)	-	-
	C/D	Maternity	G(S)	G(S)	G(S)	-	-
	E	Rocket	None	None	G(S)	-	SR
	F	Rocket	G(S)	None	G(S)	-	-
BAT_217W	A/B	Maternity	G(S)	G(S); VI(1)	G(S)	-	-
	C/D	Maternity	None	G(S)	G(S)	-	-
	E	Rocket	G(S)	None	None	-	-
	F	Rocket	None	G(S)	None	-	-
BAT_246	A/B	Maternity	None	G(S)	None	-	SR; TL
	C/D	Maternity	G(S)	None	G(S)	-	TL
	E	Rocket	None	G(S)	G(S)	-	
	F	Rocket	G(S)	G(S)	G(S)	-	TL
BAT_247	A/B	Maternity	None	None	G(S)	-	SR
	C/D	Maternity	None	None; VI(1)	None	-	SR
	E	Rocket	None	None	None	-	SR
	F	Rocket	G(S)	None	None	-	SR
BAT_254	A/B	Maternity	G(S)	G(S)	G(S)	-	-
	C/D	Maternity	None	G(S)	G(S)	-	-
	E	Rocket	G(S)	G(S)	G(S)	-	-

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			6-9 June	13-16 Jul	27-29 Sep,	17-21 July	
	F	Rocket	G(S)	G(S)	G(S)	-	-
BAT_258	A/B	Maternity	G(S); VI(1)	G(S); VI(2)	G(S)	-	SR
	C/D	Maternity	G(S); VI(1)	G(M); VI(9)	G(L)	-	-
	E	Rocket	G(S)	G(M)	G(L)	-	SR
	F	Rocket	G(M)	G(L); VI(7); M(1)	G(L)	-	SR
BAT_258NE	A/B	Maternity	G(L); VI(10)	G(L); VI(>30)	G(L)	VI(72)	-
	C/D	Maternity	G(L); VI(>30)	G(L); VI(5)	G(M)	VI(12)	-
	E	Rocket	G(M); VI(1)	G(L); VI(14)	G(M)	VI(38)	SR
	F	Rocket	G(L); VI(9)	G(L); VI(11)	G(S)	VI(16)	SR
BAT_272.2N	A/B	Maternity	G(L); VI(>12)	G(L); VI(>44); M(2)	G(L)	VI(46)	TL
	C/D	Maternity	G(M); VI(5)	G(L); VI(11); M(1)	G(L)	VI(26)	TL
	E	Rocket	G(L); AO	G(L); VI(1)	G(L)	VI(9)	TL
	F	Rocket	G(L); AO	G(M); AO	G(L)	VI(120)	TL
BAT_272.2S	A/B	Maternity	G(L); VI(>32)	G(L); VI(>32); M(1)	G(L); M(1)	VI(67)	-
	C/D	Maternity	G(L); VI(>16)	G(L); VI(>44)	G(L)	VI(133)	-
	E	Rocket	G(L); VI(3)	G(L); VI(10); M(1)	G(L)	VI(51)	-
	F	Rocket	G(M); AO	G(L); VI(8)	G(L)	VI(31)	-
BAT_330.2	A/B	Maternity	G(S); VI(1)	G(M)	G(M)	-	-
	C/D	Maternity	G(S); VI(2)	G(M); VI(1); M(1)	G(M)	-	-
	E	Rocket	G(M); VI(1)	G(S); VI(1)	G(L)	-	-
	Condo	Condo	G(S)	G(S)	G(S)	-	TL(2)

None – None observed; G(S/M/L) – Guano (quantity: Small/ Moderate/ Large); VI(#) – Visually observed (number observed); AO – Audibly observed; M(#) – Mortality (number collected); SD – Guano Screen Damaged; SI – Screen installed; SR; Screen repaired; TL – Temperature logger(# installed, if >1)

3.3 Species Identification

During the emergence surveys performed in the 2023 monitoring season, an Echo-Meter Touch 2 Pro ultrasonic detector (Wildlife Acoustics) was used concurrently to monitor and record bat activity. Audio recordings were analyzed manually (Sonobat North American, 4.4.5). Results are presented in Table 3.

Greater than 41 % of the call passes recorded during the emergence surveys were identified as high frequency or social calls, which were likely produced by myotis species but whose call characteristics would not permit an individual species identification. Although little brown myotis were positively identified from a small subset of calls from BAT_145 and 272.2N, these calls can't definitively be identified as bats from the bat boxes because the detection radius of the recorders is larger than the area viewed by the observers, and bats flying in the vicinity may be from other roosts. At all four sites with recordings, calls typical of myotis species were present. It should be noted that acoustic differentiation between myotis species relies on 'search phase' call types and that calls from within the bat boxes or from newly emerged bats may not yet be employing this call type (e.g., Fraser et al. 2020).

The acoustic identification of bat species emerging from their roosts is challenging in isolation. Other identification methods, such as mist-netting and genetic samples, are better suited for more definitive determination of species presence. Nevertheless, bat detectors that are audible to observers are a useful tool to aid the observation of bat activity at roost box sites. It should be noted that little brown Myotis was already confirmed at BAT_145 and 272.2N through DNA analysis (Golder 2022).

Table 3: Summary of Bat Calls Recorded During Emergence Counts

Site	Number of Bats Observed Emerging (bats remaining within boxes after survey)	Number of Ultrasonic Recordings	Duration of Survey	Manual call IDs – Total Number (% of Recorded Calls)
BAT_145	167 (8)	193	1 hr 36 min (21:04 – 22:40)	High Frequency – 5 (2.6 %) Myotis – 120 (61.9 %) Social – 51 (26.3%) Mylu – 6 (3.1 %) Low Frequency – 12 (6.2 %)
BAT_153	172 (6)	286	1 hr 58 min (21:04 – 23:02)	High Frequency – 7 (2.4 %) Myotis – 116 (40.6 %) Social – 143 (50.0%) Myvo – 1 (0.3 %) Low Frequency – 19 (6.6 %)
BAT_258NE	129 (8)	Issue with recorder prevented recordings	-	-
BAT_272.2N	198 (3)	161	1 hr 48 min (21:06 – 22:54)	High Frequency – 4 (2.5 %) Myotis – 99 (61.5 %) Social – 30 (18.6%) Mylu – 17 (10.6 %) Low Frequency – 11 (6.8 %)
BAT_272.2S	267 (15)	97	2 hr 0 min (20:58 – 22:58)	High Frequency – 11 (11.3 %) Myotis – 9 (9.3%) Social – 54 (55.7%) Low Frequency – 23 (23.7 %)

Mylu – *Myotis lucifugus* (little brown myotis), Myvo – *Myotis volans* (long-legged Myotis), Social calls –these exhibit greater frequency range and often include upsweeps (not diagnostic to species level but are likely Myotis).

3.4 Temperature Logger Data

Temperature loggers were installed within a subset of boxes to help understand the range of temperatures present within installed roost box types and establish a dataset over time to examine whether temperature differences may influence occupancy. A total of 14 temperature loggers (HOBO MX2201), recording temperature data every five minutes, were installed in 13 boxes at five sites during 6-9 June 2023 (BAT_21.4_A, C and F, BAT_153_C and F, BAT_246_A, C, F, and E, BAT_272.2N_B, C, E, and F, and BAT_330.2 Condo High and Low), and most were collected 27-29 September 2023. Sites were selected to have a variety of box types (four Rocket boxes, seven Maternity boxes, and one Bat Condo), and box colours (nine dark, and four light). Although the crew tried to avoid disturbing roosting bats during logger installation, one bat emerged from BAT_272.2N_B during this activity but flew back to the box soon after it was completed.

In determining placement for temperature loggers, it was assumed, based on data collected in 2019 and previous studies (e.g., Brittingham and Williams 2000; Hoeh et al. 2018), that thermal gradients exist within each box, ranging from a maximum temperature in the highest point of the box on the side with the greatest solar exposure, to a minimum of the ambient air temperature near the bottom opening of the box. Temperature loggers were placed in the presumed warmest location within the box. Little brown myotis have shown a preference for bat boxes that offer temperatures 8 -10 °C above ambient; however, bats will remain in bat boxes with maximum temperatures up to 53 °C by moving along a thermal gradient to cooler areas within the box (Brittingham and Williams 2000).

To simplify comparisons between boxes, recorded bat box temperatures are ideally compared on a warm clear day during July when maternity activity could be expected. Due to forest fire smoke, the best available day was July 29 although some cloud cover was present (29 July 2023; Appendix B, Figure B1). The Fort St. John airport reported a high of 25.3 °C and a low of 8.6 °C on 29 July 2023, with mainly clear skies throughout the day (Gov. Can. 2023). On 29 July 2023, the maximum bat box temperatures ranged from 2.11 °C to 27.81 °C above the maximum air temperature (mean 17.47 °C; SE 2.02 °C), with actual maximum temperature ranging from 26.21 °C to 51.91 °C (mean 41.57; SE 2.02 °C; Table 5). The presence of cloud cover makes comparisons between sites difficult since the distribution and intensity of cloud cover is uneven, as can been seen in the irregular temperature profiles (Appendix B, Figure 1).

Emergence counts were performed at two sites that had temperature loggers installed: BAT_272.2N was surveyed on 19 July 2022 and BAT_153 was surveyed on 20 July 2022. This provided an opportunity to examine occupancy where thermal properties of the bat boxes are known (Appendix B). At BAT_272.2N, boxes B (n=22), E (n=9) and F (n=120) had similar temperature profiles with a broad temperature peak, but box F's temperatures were elevated approximately 8°C in comparison. Box 272.2N_C (n=21) had a similar peak temperature as box F, but it's afternoon temperature high was a shorter duration spike. It's likely that box C's temperature spike was due to the orientation of that maternity box, but its unknown if that is significantly affected bat use. At site BAT_153, the box with the largest number of bats counted during the emergence survey (box A, n=100) did not have a temperature logger present. Of the boxes at Bat_153 that had temperature loggers installed, box F reached higher temperatures and housed more bats on the day of emergence counts (41.61 °C, n = 46) compared to box C (35.35 °C, n = 18; Table 4). Although box F reached its higher peak sooner than box C, these two boxes maintained similar afternoon and evening temperatures (Appendix B, Figure B3). A likely explanation for the differences in temperature profile is that the orientation of maternity box BAT_153 C (light colour) caused it to reach its peak later while the rocket box F (dark colour) has an orientation which allowed it to reach its peak temperature earlier in the day. Temperatures within the bat condo at site BAT_330.2 ranged from a maximum of

50.58 °C in the peak of the condo to a maximum of 26.21 °C at the base of the inner chamber on 29 July, providing a 23 °C gradient during the warmest period of the day within which bats may safely change positions to their preferred thermal conditions. Although there was no obvious linear relationship between the number of bats within the boxes and the maximum daily temperatures (Table 4), the boxes with the two highest abundances both had high temperatures close to 41°C on July 29 and similar mean high temperatures (Table 4 and Figure 10).

Table 4: Maximum and Minimum Temperatures Recorded on 29 July 2023

Site	Box	Box Type	Colour	Orientation	Occupancy Survey (13-16 July)	Emergence survey	29 July 2023		
							Low (°C)	High (°C)	Sunset temperature during emergence survey (°C)
BAT_21.4	A	Maternity	Dark	N	Moderate	-	8.28	47.87	-
	C	Maternity	Light	NW	Moderate	-	8.23	48.86	-
	F	Rocket	Light	N/A	Low	-	9.22	38.39	-
BAT_153	C	Maternity	Light	NW	High; VI(11)	VI(21)	9.18	35.35	22.73
	F	Rocket	Dark	N/A	High; VI(2)	VI(46)	9.14	41.61	21.06
BAT_246	A	Maternity	Light	N	Low	-	6.26	44.61	-
	C	Maternity	Dark	NE	None	-	6.48	51.91	-
	F	Rocket	Dark	N/A	Low	-	7.68	43.37	-
BAT_272.2N	B	Maternity	Dark	SE	High; VI(14)	VI(46)	8.45	31.83	23.46
	C	Maternity	Light	N	High; VI(6)	VI(26)	9.48	45.94	21.96
	E	Rocket	Light	N/A	High; VI(1)	VI(9)	11.79	34.75	22.13
	F	Rocket	Dark	N/A	High	VI(120)	8.11	40.75	28.01
BAT_330.2	Condo High	Condo	Dark	N/A	Low	-	15.40	50.58	-
	Condo Low						8.79	26.21	-

[1]Occupation evaluation based on quantity of guano present beneath box or visual observation (VI).

Roost box mean daily maximum temperatures are presented in Figure 10, along with available emergence counts and guano amounts from the July occupancy surveys. Currently, there is no obvious relationship between temperature and occupancy levels. Rather, the location of the boxes appears to be the primary predictor of bat use, and boxes located near previously identified bat colonies often support the largest populations (e.g., BAT_145, BAT_153, 272.2S and 272.2N). It should be noted that guano amounts often do not correlate to emergence counts (e.g. the highest occupancy level was matched to a medium amount of guano at Bat 22.2N_F). The logical reason for these discrepancies would be roost switching in the later part of the period between the June and July occupancy surveys. To examine if there is a relationship between roost temperatures and roost switching, the frequency of monitoring surveys would need to be increased.

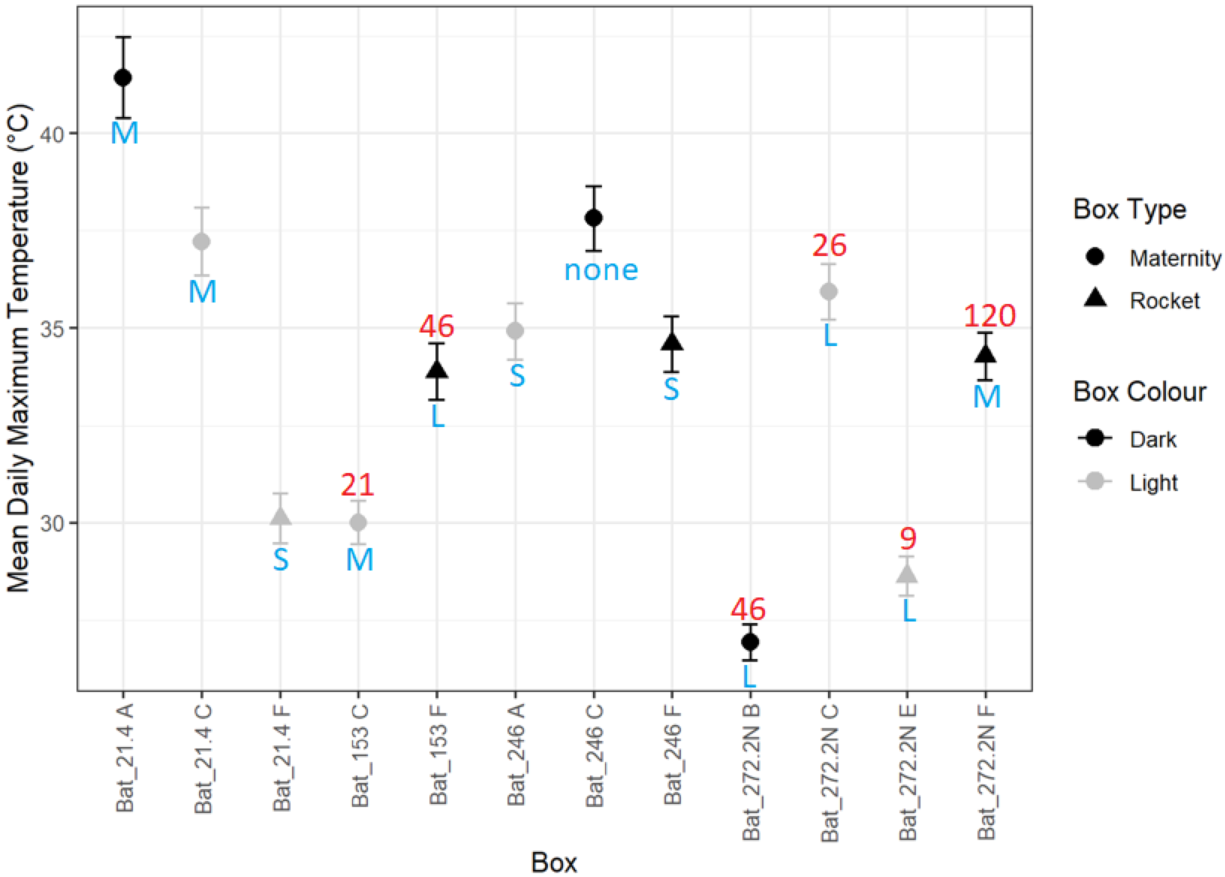


Figure 10: Mean (±SEM) maximum daily temperature recorded within individual bat boxes during June through September 2023, with and without recorded mortalities (guano amount from July occupancy survey in blue (Small/Medium/Large) and bat count from emergence survey in red).

A two-way ANOVA was used to test differences in maximum daily temperature between box types and box colours from data pooled from all field seasons to date (Figure 11). As temperature loggers were only installed in the top of boxes in 2020, 2021, 2022, and 2023, only loggers installed in the top of boxes in 2019 were included. The condo was not included in the statistical analysis since only one colour of condo was installed. A significant difference between types ($F(1,5442)=207.8$, $p < 0.001$) and colours ($F(1, 6798)=206.6$, $p < 0.001$) were both found. These effects have been qualified by a significant interaction between box type and box colour ($F(1, 6798)=13.8$, $p < 0.001$). Subsequent post-hoc comparison, subjected to a Bonferroni-adjusted p-value, between the closest groups revealed significant differences in maximum daily box temperature between the dark maternity boxes and dark rocket boxes ($t=8.07$, $p < 0.001$), and light maternity boxes and light rocket boxes ($t=12.11$, $p < 0.001$; Figure 11). No differences were revealed between light maternity boxes and dark rocket boxes ($t= 0.029$, $p=1$). These data suggest that while both colour and type influence maximum daily temperature, generally maternity boxes tend to achieve slightly warmer daily temperatures than rocket boxes. While it was excluded from the statistical analysis, the bat condo tends to achieve higher maximum temperatures than any other box category when all years of data are combined.

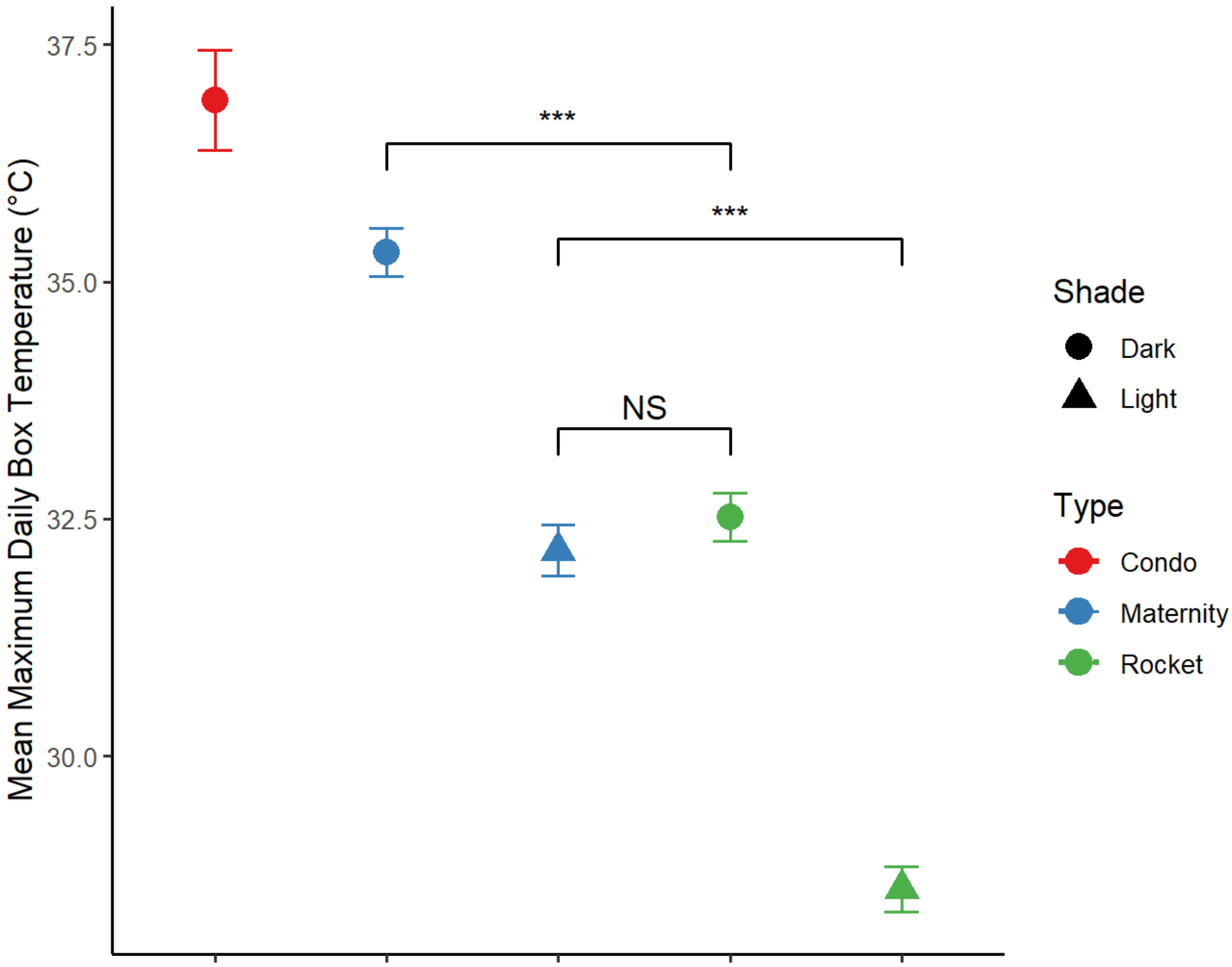


Figure 11: Mean (±SEM) maximum daily temperature recorded within each bat box category using data pooled from all survey years. NS indicates p>0.05, * indicates p<0.0001. The condo was excluded from the statistical analysis.**

Although the upper portion of some boxes may have reached temperatures unsuitable for bat roosting (i.e., 53°C is an experimental threshold temperature for bats to remain within a bat box [Brittingham and Williams 2000]), bats are able to access the lower edges of the boxes, areas adjacent to box vents and north-facing paired boxes where temperatures should approximate more suitable ambient temperatures.

3.5 Mortalities

During July and September occupancy and emergence surveys, a total of eleven bat mortalities were recorded at five different monitoring sites (Table 5). During occupancy surveys on July 13 and 14, 9 carcasses were recorded at the three sites beneath seven boxes (or box pairs). A single carcass was identified during emergence surveys at 272.2S on July 17. An additional carcass was identified and collected during the September occupancy check at 272.2S. Following the discovery of bat mortalities, WSP contacted BC Hydro and the Province of BC and relayed the information. Details of the mortalities, and mortality sites were provided, and the samples were frozen. In consultation with Gavin Hanke, vertebrate zoology curator, of the Royal BC Museum, WSP transferred the specimens to the museum for addition to its archives. No results from the 2022 mortality specimens submitted to the Provincial Animal Health Care Center were available at the time of reporting.

No mortalities were recorded during monitoring surveys in 2019, 2020, or 2021. However, 19 mortalities were documented in 2022 (WSP 2023) and 11 in 2023. Environment Canada data from the Fort St. John airport (ECCC 2023) suggests similar extreme, average daily maximum and average mean daily temperatures for the month of July in 2021, 2022, and 2023 (30.9/23/17.3ºC, 30.6/23.3/17.7ºC, and 32.2/23.7/17.6ºC, respectively). Precipitation totals differed between the years for July with 40.1 mm in 2021, 21.4 mm for 2022, and 25.4 mm in 2023. It is also unknown to what extent bat mortalities were scavenged and unrecorded, but photos indicate that some of the mortalities persisted long enough to decompose and accumulate guano on top of them (Appendix A, photos 20 and 21). These mortality sites represent some of the highest observed bat counts for the project (Table 2) and the most likely scenario to account for the mortalities is accidental falls, however, this is purely speculative given the limited data. The mortality identified at BAT_330.2 was the only adult mortality recorded during the July occupancy surveys. It should be noted that the presence of pups does confirm maternity activity at those sites.

Table 5: Documented bat mortalities for 2023 surveys.

Bat Site	Box ID	Box Type	Number of Mortalities (July survey date)	Number of Mortalities (July emergence survey date)	Number of Mortalities (September survey date)
153	A/B	Paired BCI maternity boxes	2 (July 14)	0 (July 20)	0 (September 28)
258	F	Double layer rocket box	1 (July 13)	0 (NA)	0 (September 27)
272.2N	A/B	Paired BCI maternity boxes	2 (July 13)	0 (July 19)	0 (September 27)
	C/D	Paired BCI maternity boxes	1 (July 13)	0 (July 19)	0 (September 27)
272.2S	A/B	Paired BCI maternity boxes	1 (July 13)	0 (July 17)	1 (September 27)
	E	Double layer rocket box	1 (July 13)	1 (July 17)	0 (September 27)
330.2	C/D	Paired BCI maternity boxes	1 (July 13)	0 (NA)	0 (September 27)

For boxes where temperature data was collected, a mixed-effects model was used to test if there was a significant difference in maximum temperatures between boxes with and without recorded mortalities in 2022 and 2023. The model had two fixed effects interactions – an interaction between a spline of the effect of week and year, to account for seasonal changes in temperature and differences between years, and an interaction of presence or absence of mortality at each box with year, to account for expected changes in mortality between years. The random effects were a random intercept of bat box and a random intercept of week, as a categorical variable. The latter accounted for the weekly variability, while allowing the fixed effect of week to capture the seasonal trend in temperature. The time series of data was summarized to a weekly resolution, to reduce the extent of temporal autocorrelation in the data. For each box, the weekly maximum temperature was calculated.

The fitted model described varying seasonal temperature trends between each year, with maximum weekly temperature increasing from 29.9 °C (2022, for boxes without mortality) in the week of 01 June to 05 June, to 44.9 °C in the week of 26 June, decreasing again before leading to a maximum of 50.1 °C during the week of 24 July (Figure 12). The temperature trend in 2023 was much more stable with weekly temperatures (for boxes without mortality) ranged between 42.1 and 44.3 °C (Figure 12). The estimated difference in maximum weekly temperature between boxes with and without mortalities in 2022 was 5.14 °C (SE of 3.22 °C). That is, boxes where mortalities were recorded were on average 5.14 °C hotter than boxes without mortalities. Whereas the estimated difference in maximum weekly temperature between boxes with and without mortalities in 2023 was 5.27 °C (SE of 4.33 °C). That is, boxes where mortalities were recorded were on average 5.27 °C cooler than boxes without mortalities. Due to the low sample size of boxes with mortalities (18 boxes without mortalities and only 6 boxes with recorded mortalities) and the high variability between boxes, this difference was not statistically significant (2022, p=0.11; 2023, p = 0.23). It should be noted that the ability of the model to detect significant differences is diminished by low temporal resolution of when the mortalities occurred.

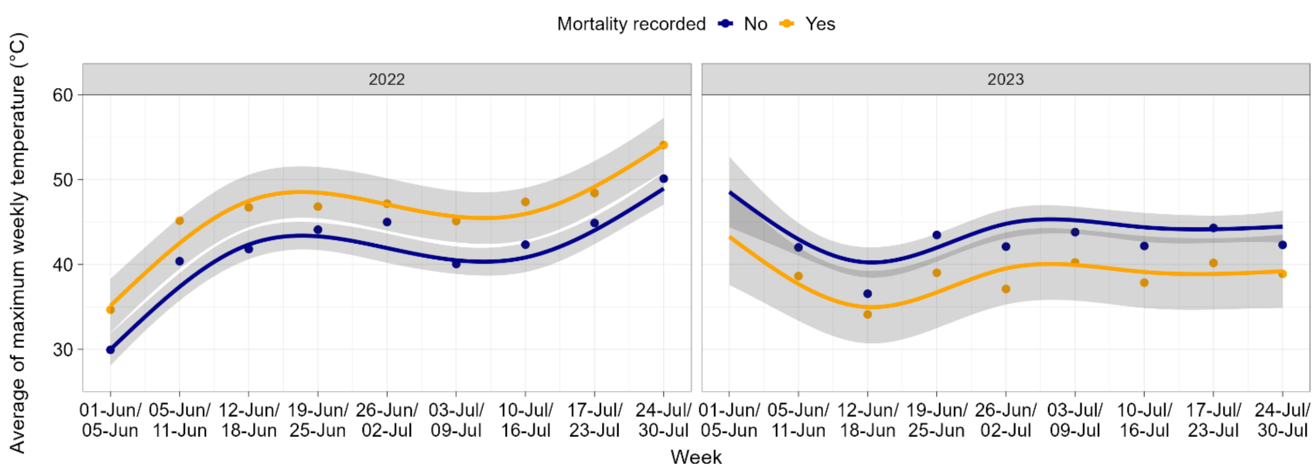


Figure 12: Fitted mixed-effects model for maximum weekly temperature in relation to recorded mortality. Shaded areas indicate the 95% confidence intervals for the modeled data.

While the bats may have experienced some heat stress in 2022 and 2023, it is unlikely that maximum temperatures were the sole factor for the observed mortalities given the lack of a consistent trend between years. Installed bat boxes are designed to include a range of temperatures, including ambient, and the close proximity of various box designs and colours is intended to offer the bats a spectrum of choices depending on the thermal requirements of the season. Further, no mortalities were observed during the summer of 2021, when occupied boxes recorded similar or higher temperatures (e.g., 58.6°C for BAT_272.2N B on 29 June 2021). Other confounding factors such as availability of drinking water and occupancy level of boxes are likely to play a role in mortalities. We are also uncertain if the sensitivity of bat pups to high temperatures varies with age, but younger bat pups can be carried between roosts by their mothers, possibly moving to roosts where temperatures are more suitable. During warmer temperatures, bats can be seen congregating at the lower edge of bat boxes which increases the likelihood of falls, especially at boxes with high occupancy. Pre-volant juvenile bats, unlike the adults, can't return to the box unassisted if they fall. As occupancy rates at the bat boxes increase, low rates of juvenile mortality are likely to persist but typical mortality rates for bat boxes have not yet been established (pers comm. Mandy Kellner 2022).

3.6 Bat Box Condition Inspection

Installed bat boxes were observed to be in relatively good shape. No new damage to the boxes was observed over the course of 2023. Previously reported minor damage remains on some boxes, but their structural integrity has not been compromised. The most common type of damage observed is missing portions of roof shingles, where overhanging portions have fallen off. In some cases, it looks like the shingle has ripped, leaving small portions of the roof without a shingle cover.

Guano screens were damaged to varying degrees in several locations (Table 2). Observed damage consisted mainly of small holes and tears in the screen itself, which were mended in the field using zip-ties. Additional minor screen damage was repaired where possible, but some screens will require minor repairs in the spring of 2024 (Appendix A, photo 7).

In 2020, the frames at several sites were destroyed likely by livestock or wild animals (BAT_21.4, BAT_82.1, BAT_272.2N, and BAT_272.2S), and so a new guano screen was designed and installed at these locations in May 2021 (Appendix A, photo 8). Rather than standing on four legs on the ground, the new screen is attached directly to the steel pole via a single bolt 1.3 m above ground level (Appendix A, Photo 8). The frame is also made from two-by-fours instead of two-by-twos. This design allows livestock and wildlife unrestricted access to the ground beneath the screen, and the more robust frame components are capable of withstanding greater interaction with livestock and wildlife. During the 2023 monitoring period, the majority of these screens remained in excellent condition with no screen tears or frame breaks, however, one screen at BAT_21.4 was completely destroyed and will require additional material to rebuild it in 2024 (Appendix A, Photo 9).

3.7 Adaptive Management

More recently, the Site C Bat Mitigation and Monitoring Program document was revised (BC Hydro 2022) to summarize the current programs and detail the program objectives. The objectives for bat box monitoring included the following points related to adaptive management:

- Roost boxes not being used within four years of installation will be moved to another location or additional boxes will be constructed at the new location(s).
- A selection of boxes with documented use by large numbers of bats will be identified for long-term (e.g., 20 years) or permanent (for the life of the Project) retention and monitoring.
- All boxes used by little-brown myotis or northern myotis will be retained for the life of the Project.

All of the bat box sites surveyed in 2023 had some recorded bat activity aside from BAT_55 which was only surveyed at the end of the season and had damaged screens. When excluding the boxes from sites that didn't receive three occupancy surveys in 2023 (BAT_48, 53, 55 and 62), only one bat box had no recorded bat activity in 2023: BAT_247 E. Given that only one box had no recorded activity and that the variety of box types and colours at a site are intended to provide the bats different microclimates, WSP doesn't recommend moving any boxes to new locations at this time. It should be noted that the absence of bat guano does not necessarily exclude bat activity at a box, as indicated by BAT_247 C/D where a single bat was visually observed in the absence of any recorded guano during 2023.

Roost sites where federally listed Species At Risk bats are present or at least 10 individuals of any bat species are identified, are presented in Table 6. There are two federally listed bat species that have the potential to be recorded in bat boxes in the study area: the little brown myotis and the northern myotis (*Myotis septentrionalis*), both of which are federally listed as Endangered Schedule 1, by the Species at Risk Act (SARA 2022). As per the adaptive management criteria identified above, boxes with large numbers of bats may be given long-term or permanent retention and monitoring. If guano DNA sampling is included in future monitoring years, it is recommended that sites without DNA sampling (Table 6) be prioritized, to assess for the presence of listed bat species.

Table 6: Roost sites identified for long-term or permanent retention and monitoring

Site	10 or more bats documented (year)		Listed Species Identified by guano DNA in 2021	Recommended retention	
	Occupancy Survey	Emergence Count		Long-term	Permanent
BAT_21.4			Mylu	No	Yes
BAT_48			not sampled	-	-
BAT_53			not sampled	-	-
BAT_55			not sampled	-	-
BAT_62			not sampled	-	-
BAT_82.1			Mylu	No	Yes
BAT_134			Mylu	No	Yes
BAT_144			not sampled	-	-
BAT_145		130 bats (2022), 175 bats (2023)	Mylu	Yes	Yes
BAT_153	10 bats (2021)	178 bats (2023)	Mylu	Yes	Yes
BAT_217E			not sampled	-	-
BAT_217W			non-listed species	No	No
BAT_246			Mylu	No	Yes
BAT_247			Mylu	No	Yes

Site	10 or more bats documented (year)		Listed Species Identified by guano DNA in 2021	Recommended retention	
	Occupancy Survey	Emergence Count		Long-term	Permanent
BAT_254			not sampled	-	-
BAT_258	10 bats (2020), 18 bats (2023)		non-listed species	No	No
BAT_258NE		17 bats (2021) 69 bats (2022), 138 bats (2023)	Mylu	Yes	Yes
BAT_272.2N	20 bats (2022)	26 bats (2020), 96 bats (2021), 201 bat (2023)	Mylu	Yes	Yes
BAT_272.2S	61 bats (2022)	10 bats (2020), 105 bats (2021), 282 bats (2023)	Mylu	Yes	Yes
BAT_330.2		20 bats (2021) 15 bats (2022)	Mylu	Yes	Yes

Mylu – *Myotis lucifugus,* little brown myotis (Endangered, SARA Schedule 1)

Although the condo structure has the ability to house the largest number of bats compared to the other box designs present, only small amounts of guano have ever been recorded there and the largest number of bats observed was two, during an emergence survey in 2022 (Appendix C and Golder 2023). Although other structures at BAT_330.2 have seen greater success than the condo, the overall numbers are not high (n=15 bats, 2022 emergence survey; Appendix C). It is possible that given the limited number of bats using the site, that the maternity and rocket design boxes are more suited for small clusters of bats to huddle during colder weather to maintain higher metabolic temperatures necessary for the rearing of young. There is an option to add additional roosting surfaces inside condo to mimic the other boxes, but it is recommended that a more detailed assessment of condo internal temperatures be completed first (i.e. multiple levels and locations). Prior to contemplating condo modifications, WSP would recommend confirming the size of the safe temperature zone inside the condo during the hottest weather. Based on these results, potential modifications to the condo could be evaluated to reduce temperatures, if necessary, and adding additional internal roosting structures. It is possible that bat abundance at BAT_330.2 may increase regardless of intervention, but likely at a slower rate than seen at other mitigation sites.

4.0 FUTURE MONITORING

Should bad box occupancy monitoring be undertaken in 2024 the suggested schedule and requirements would consist of the following activities to be conducted at bat boxes:

- three occupancy surveys at each box including visual species identification where possible;
- one emergence count at five bat box sites;
- temperature loggers in a subset of boxes which were occupied and unoccupied during 2022; and
- assessment of condition of each of the installed boxes.

In addition to these surveys, collection and analysis of guano for DNA species identification would be recommended in 2024.

Table 7: Bat Box Monitoring Program Effort

Monitoring Effort	Bat Site
5 years	21.4, 134, 153, 246, 247, 254, 258, 258NE, 272.2N, 272.2S
4 years	48, 53, 55, 62, 82.1, 144, 145, 217E, 217W, 330.2
3 years	145_G

5.0 LIMITATIONS

This report has been prepared by WSP Canada Inc., for BC Hydro solely for the use of BC Hydro, in partial fulfilment of the terms and conditions of the Outline Agreement No. 4600001896. This report is limited to the field data, collected under the supervision of WSP, to assess occupancy of the bat house sites installed as of May 2019.

The findings and conclusions documented in this report have been prepared for specific application to this Project and have been developed in a manner consistent with the level of care normally exercised by environmental professionals currently practicing under similar conditions in the jurisdiction. WSP makes no other warranty, expressed or implied.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. WSP accepts no responsibility for damages, if any suffered, by any third party as a result of decisions made or actions based on this report.

6.0 CLOSURE

We trust that this report provides sufficient information for your needs. If you have questions, please do not hesitate to contact the undersigned.

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APPENDIX A

Photos

Photo 1: Example of a typical bat box site, featuring four maternity boxes and two rocket boxes on four poles with guano screens installed underneath.

Photo 2: Example of a typical maternity box pair sharing a pole at site BAT_272.2N.

Photo 3: Example of a rocket box mounted on a steel pole at site BAT_272.2S.

Photo 4: The bat condo, at site BAT_330.2.

Photo 5: **Example of a guano screen at BAT_144.**

Photo 6: A large amount of guano was found at BAT_145_G on 14 July. Wooden ledge beneath box intended to capture guano in lieu of a screen.

Photo 7: Example of a guano screen destroyed by livestock or wildlife at BAT_153 C/D, 14 July 2023.

Photo 8: Example of the more robust guano screens.

Photo 9: Robust guano screen destroyed by livestock or wildlife at Bat_21.4 E on 8 June 2023.

Photo 10: The interior of the bat condo at BAT_330.2.

Photo 11: Example of a 'Small' quantity of guano observed beneath BAT_246 F on 14 July 2023.

Photo 12: Example of a 'Moderate' quantity of guano beneath BAT_82.1 C/D on 15 July 2023.

Photo 13: Example of a typical 'Large' quantity of guano observed beneath BAT_272.2N F on 13 July 2023.

Photo 14: An atypically "Large" quantity of guano beneath BAT_145 C/D on 14 July 2023.

Photo 15: A bat observed outside of BAT_258 A/B on 7 June 2023.

Photo 16: Emergence survey at BAT_258NE, demonstrating the perspective of the observers with the boxes silhouetted against the sky.

Photo 17: A temperature logger in maternity box BAT_21.4 A on 15 July 2023

Photo 18: A temperature logger in rocket box 272.2N F on 13 July 2023

Photo 19: Superficial damage to the exterior of BAT_82.1 E in July 2022 (left) has not worsened since June 2023 (right).

Photo 20: Bat mortality observed at BAT_272.2S A/B on 13 July 2023.

Photo 21: Bat mortalities observed beneath BAT_153 A/B on 14 July 2023.

APPENDIX B

Temperature Data

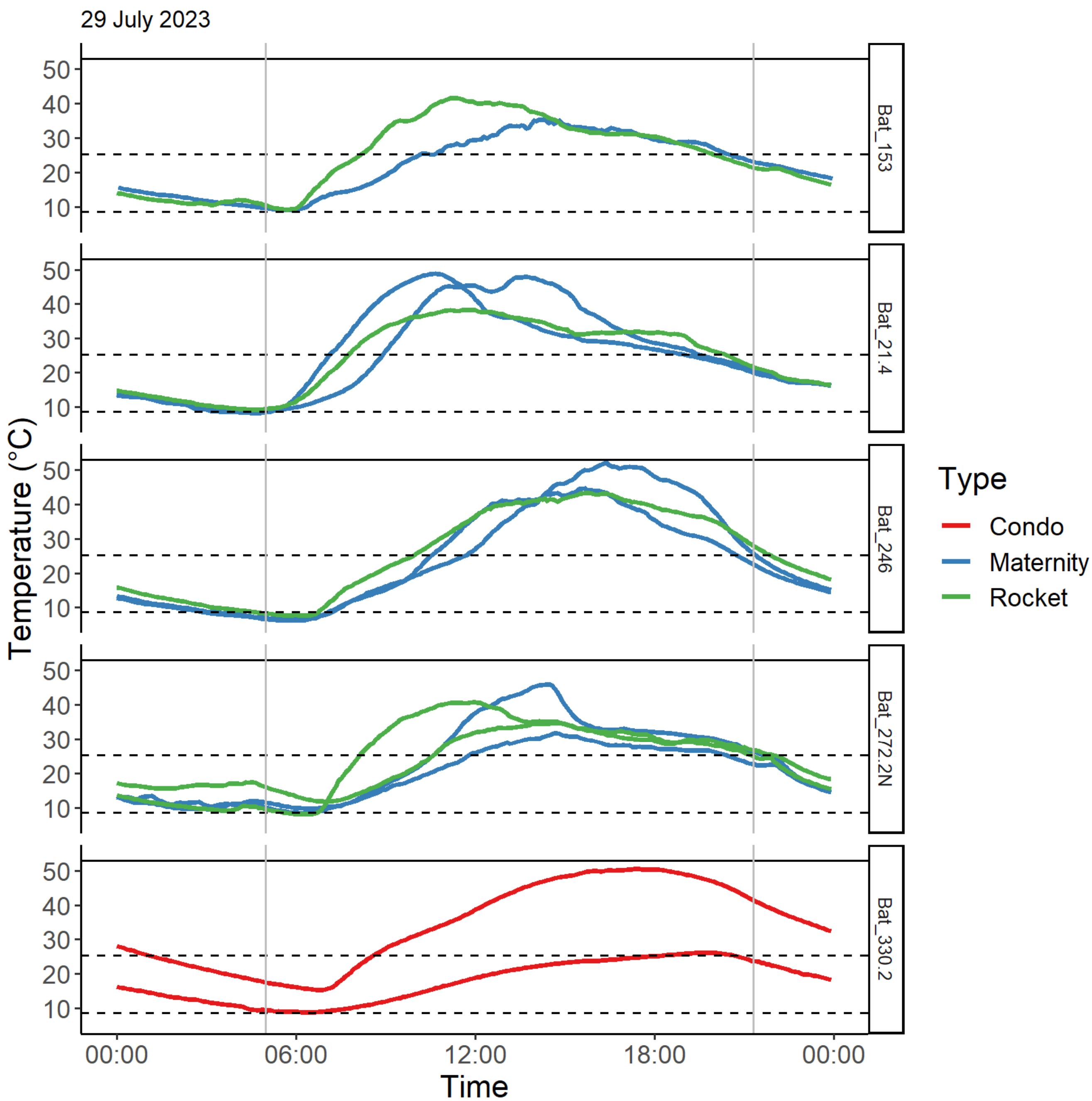

Figure B1: Temperature recorded from data loggers on a relatively warm mid-summer day, 29 July 2023, spilt by site. Each line represents the temperature in the assumed warmest location of each box, except in the case of the bat condo where loggers were installed both in the roof peak (warmer) and at the bottom (cooler) of the interior of the structure. Maximum and minimum daily air temperature recorded at the Fort St John airport presented as horizontal dashed lines. Sunrise (5:00) and sunset (21:17) times are presented as vertical grey lines.

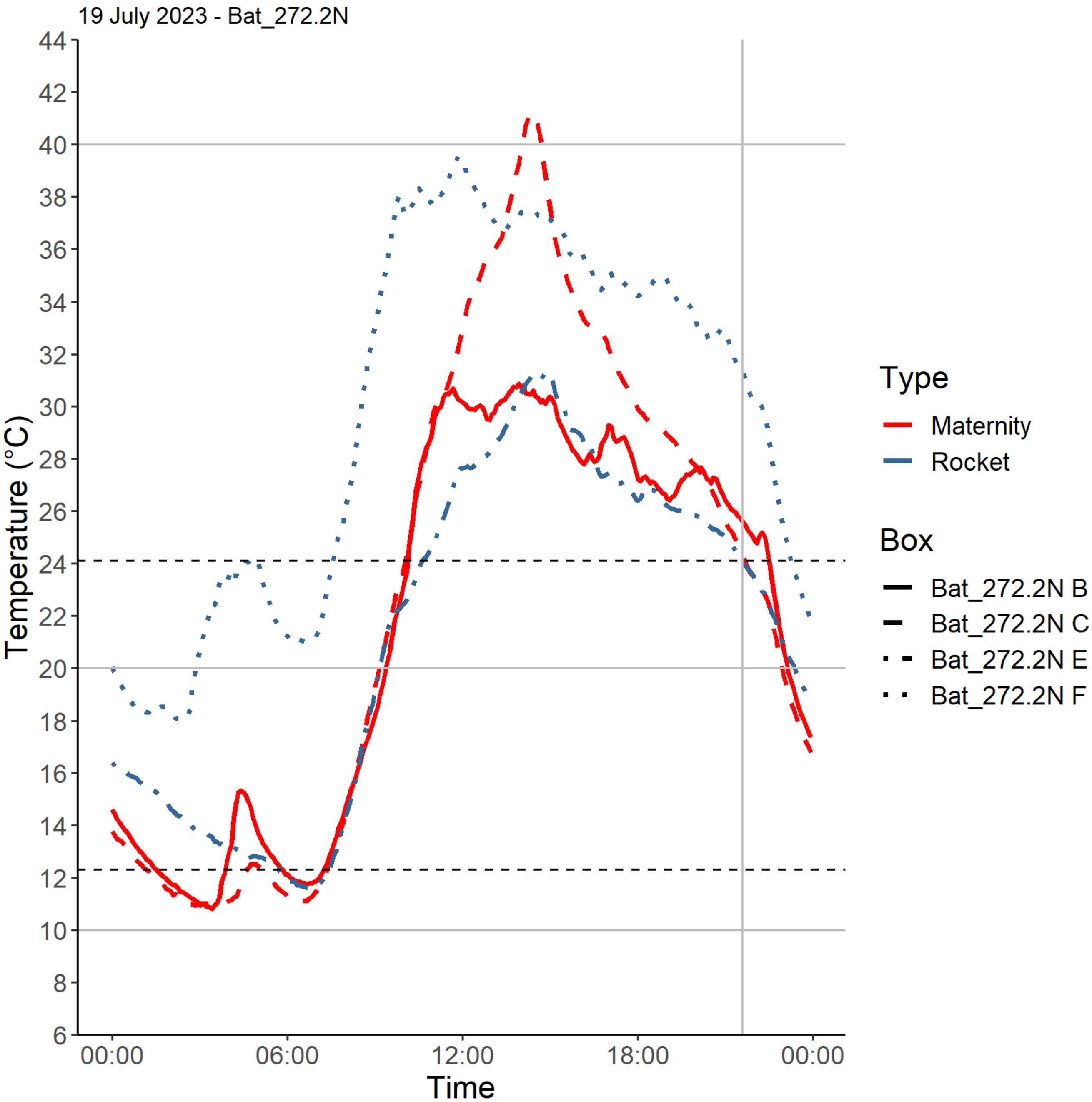

Figure B2. Bat Box temperatures at site 272.2N on the day of the emergence survey, 19 July 2023. Maximum and minimum air temperature recorded from the Fort St John airport are presented as horizontal dashed lines. Reference lines are present at 10 °C intervals. Sunset (21:38) is indicated with a vertical grey line.

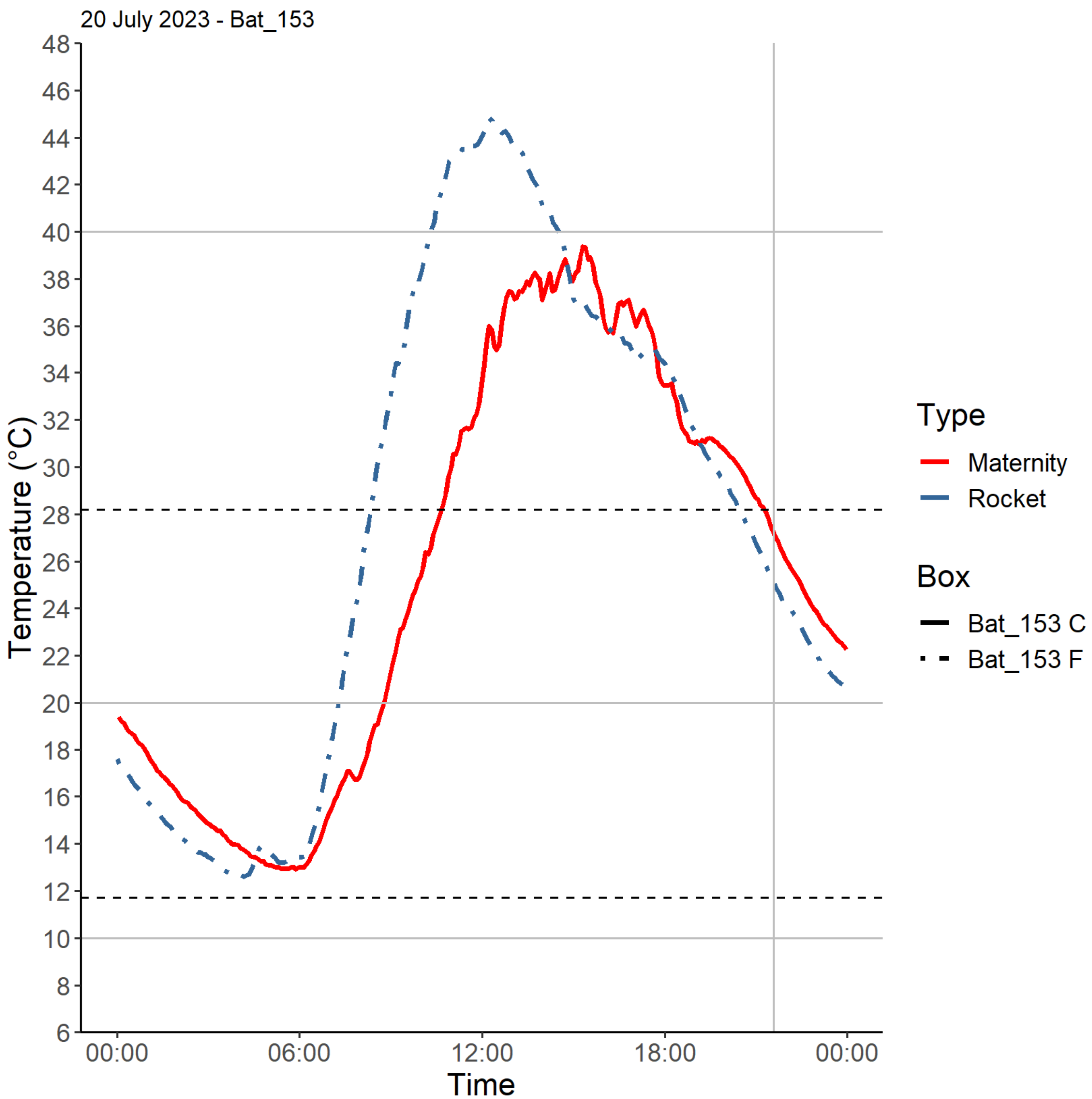

Figure B3. Bat Box temperatures at site 153 on the day of the emergence survey, 20 July 2023. Maximum and minimum air temperature recorded from the Fort St John airport are presented as horizontal dashed lines. Reference lines are present at 10 °C intervals. Sunset (21:36) is indicated with a vertical grey line.

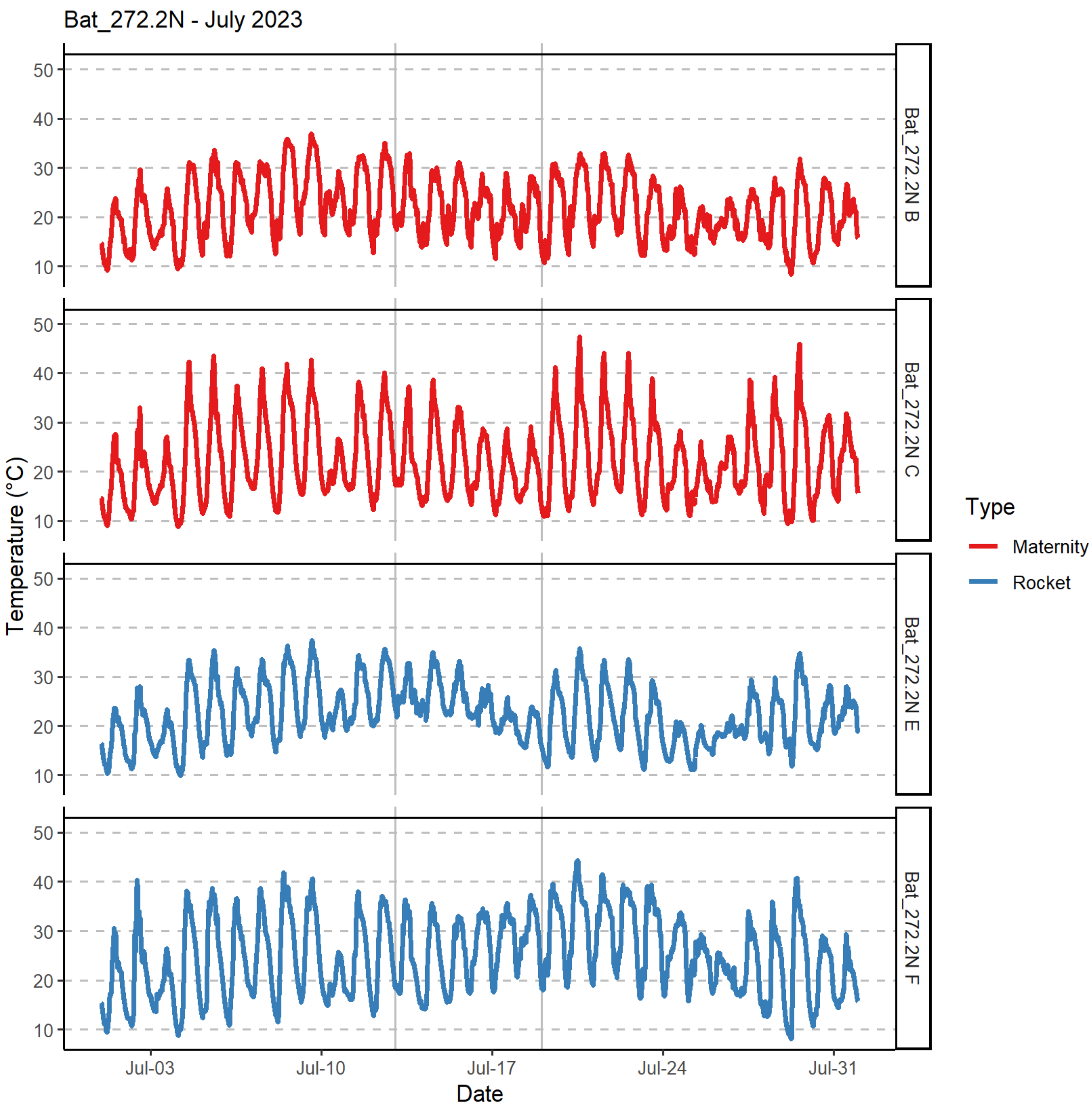

Figure B4: Temperatures of boxes at site BAT_272.2N in July 2023. Occupancy (13 July 2023) and emergence surveys (19 July 2023) are indicated by vertical grey lines. Reference lines are present at 10 °C intervals. Mortalities were observed beneath boxes A/B and C/D on July 13. No mortalities were recorded on 19 July. Bats have been recorded remaining in boxes up to a maximum temperature of 53 °C (solid black line) by moving between thermal gradients within the box (Brittingham and Williams 2000).

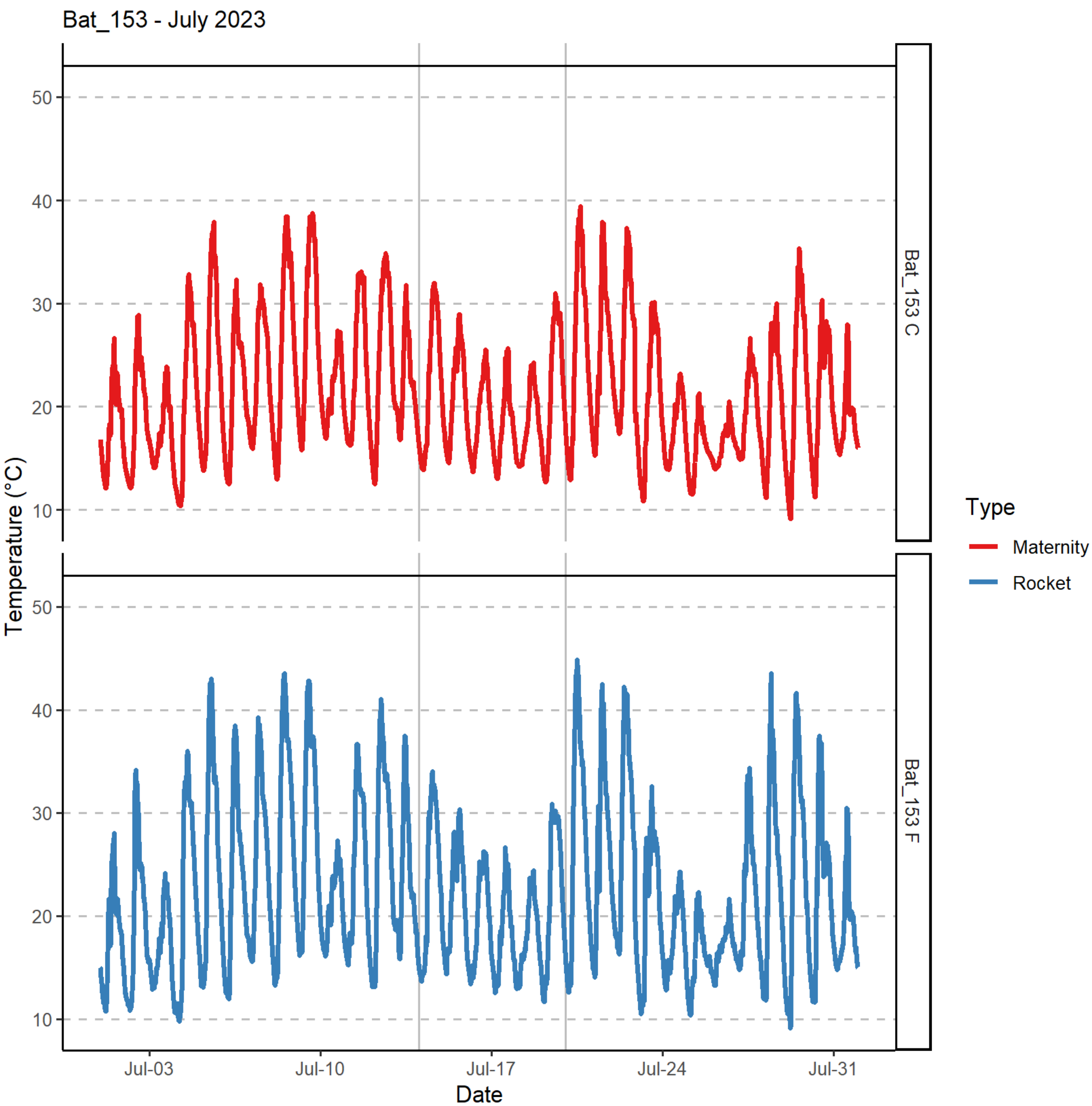

Figure B5: Temperatures of boxes at site BAT_153 in July. Occupancy (14 July 2023) and emergence surveys (20 July 2023) are indicated by vertical grey lines. Reference lines are present at 10 °C intervals. Mortalities were recorded on July 14 beneath boxes A/B, while no mortality was observed on July 20. Bats have been recorded remaining in boxes up to a maximum temperature of 53 °C (solid black line) by moving between thermal gradients within the box (Brittingham and Williams 2000).

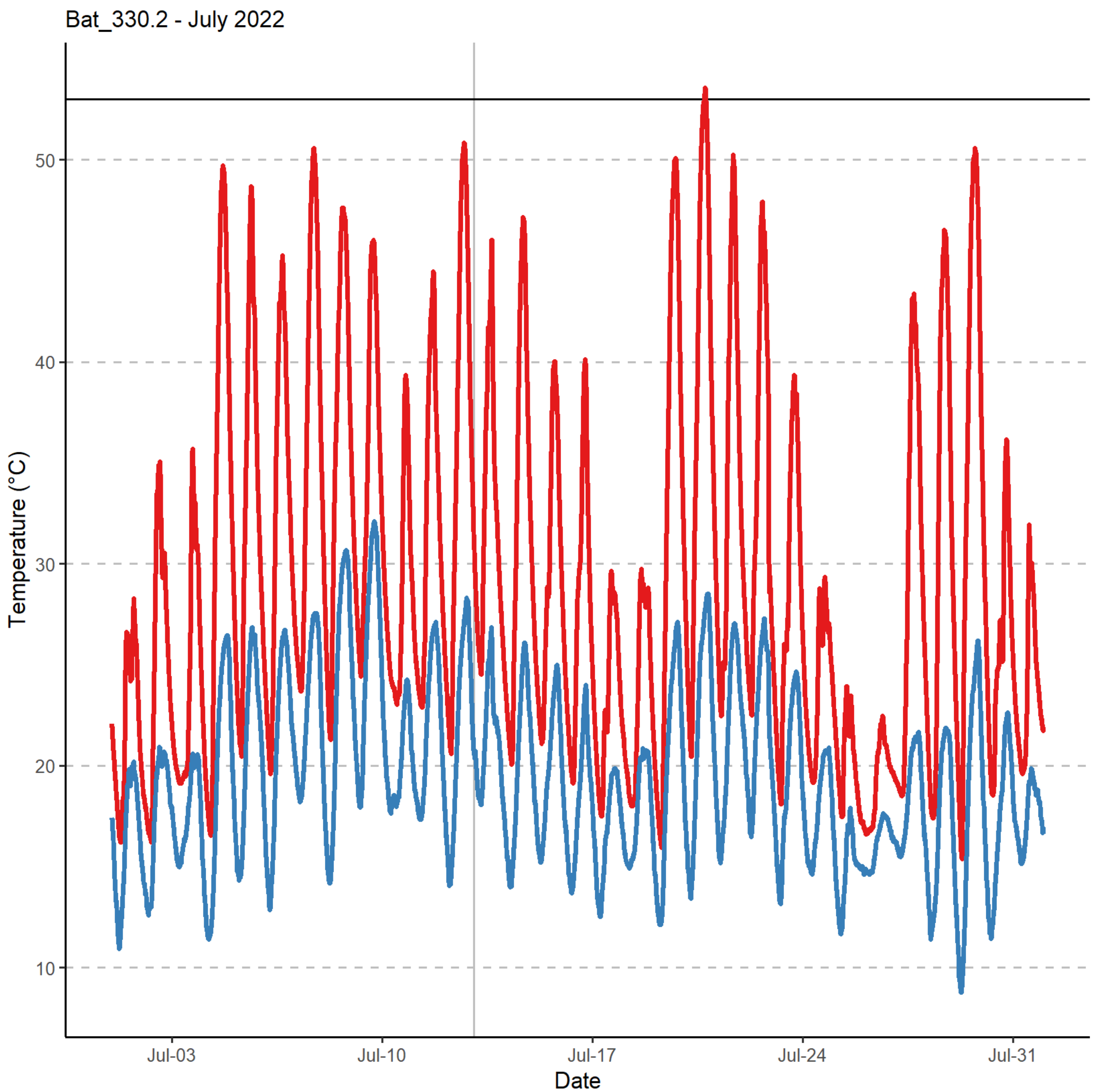

Figure B6: Temperatures recorded within the top (red) and bottom (blue) of the Condo interior at site BAT_330.2 in July, showing the thermal gradient within the structure. Occupancy survey (13 July 2023) is indicated by vertical grey lines. Reference lines are present at 10 °C intervals. Bats have been recorded remaining in boxes up to a maximum temperature of 53 °C (solid black line) by moving between thermal gradients within the box (Brittingham and Williams 2000).

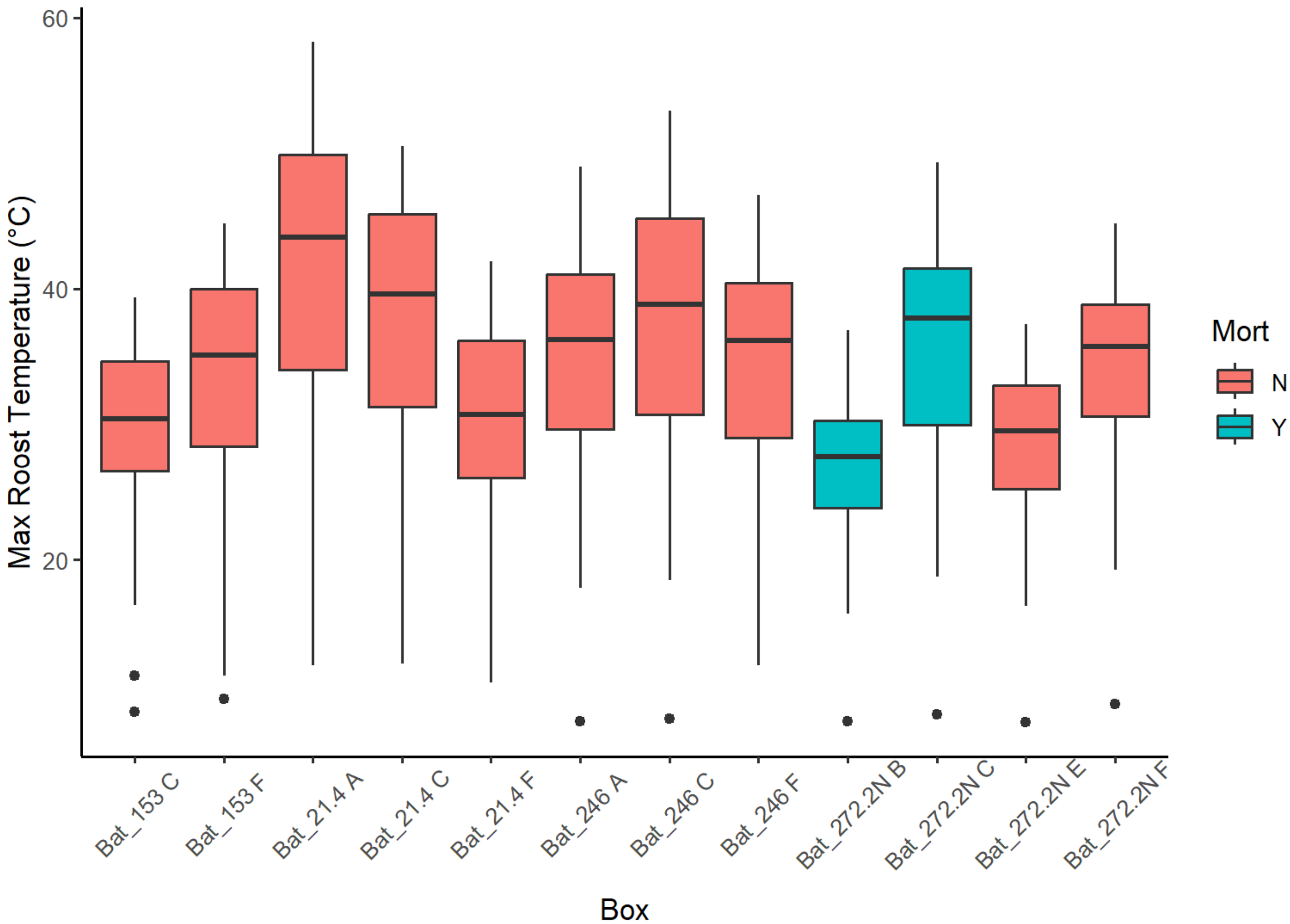

Figure B7: Boxplot of maximum daily temperatures recorded within all boxes excluding the bat condo. Data is split by boxes where mortality was recorded (blue) and not recorded (red).

APPENDIX C

2019, 2020, 2021, and 2022 Occupancy Surveys

Table C1: Bat Occupancy and Emergence Survey Results 2019

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			14-17 May	22-23 Jul	26-27 Sep	24 Jul	
BAT_21.4	A/B	Maternity	None; SI	None	G(S)	-	SB
	C/D	Maternity	None; SI	None	G(S)	-	SB
	E	Rocket	None; SI	None	G(S)	-	-
	F	Rocket	None; SI	None	G(S)	-	-
BAT_134	A/B	Maternity	None; SI	None	G(S)	-	-
	C/D	Maternity	None; SI	None	G(M)	-	SB
	E	Rocket	None; SI	None	G(S)	-	SB
	F	Rocket	None; SI	G(S)	G(S)	-	-
BAT_153	A/B	Maternity	None; SI	None	G(S)	-	-
	C/D	Maternity	None; SI	None	G(S)	-	-
	E	Rocket	None; SI	None	G(S)	-	-
	F	Rocket	None; SI	None	G(M)	-	-
BAT_246	A/B	Maternity	None; SI	G(S)	G(S)	-	-
	C/D	Maternity	None; SI	None	G(S)	-	-
	E	Rocket	None; SI	None	G(S)	-	-
	F	Rocket	None; SI	G(S); VI(1)	G(M)	-	-
BAT_247	A/B	Maternity	None; SI	None	G(S)	-	TL
	C/D	Maternity	None; SI	None	G(S)	-	SB
	E	Rocket	None; SI	None	G(M)	-	SB; TL
	F	Rocket	None; SI	None	G(S)	-	SB; TL
BAT_254	A/B	Maternity	None; SI	None	G(S)	-	-
	C/D	Maternity	None; SI	None	None	-	-
	E	Rocket	None; SI	None	None	-	SB; TL(2)
	F	Rocket	None; SI	None	G(M)	-	TL(2)
BAT_258	A/B	Maternity	None; SI	G(S); VI(1)	G(M)	VI(1)	-
	C/D	Maternity	None; SI	G(S); VI(1)	G(M)	None	TL(4)
	E	Rocket	None; SI	G(S)	G(S)	VI(1)	-
	F	Rocket	None; SI	G(M)	G(S)	None	-
BAT_258NE	A/B	Maternity	None; SI	G(S)	G(S)	-	-
	C/D	Maternity	None; SI	G(M); VI(1)	G(S)	-	-
	E	Rocket	None; SI	G(M)	G(M)	-	-
	F	Rocket	None; SI	G(M)	G(M)	-	-
BAT_272.2N	A/B	Maternity	None; SI	None	G(S)	-	TL
	C/D	Maternity	None; SI	None	None	-	TL
	E	Rocket	None; SI	None	G(S)	-	-
	F	Rocket	None; SI	G(S)	None	-	TL
BAT_272.2S	A/B	Maternity	None; SI	G(M); VI(2)	G(L)	None	-
	C/D	Maternity	None; SI	G(M)	None	VI(1)	SB
	E	Rocket	None; SI	G(M)	G(L)	VI(1)	-
	F	Rocket	None; SI	G(M)	None	None	SB

None – None observed; G(S/M/L) – Guano (quantity: Small/ Moderate/ Large); VI(#) – Visually observed (number observed); AO – Audibly observed; M(#) – Mortality (number collected); SD – Guano Screen Damaged; SI – Screen installed; SR; Screen repaired; TL – Temperature logger(# installed, if >1)

Table C2: Bat Occupancy and Emergence Survey Results 2020

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			14-17 May	22-23 Jul	26-27 Sep	24 Jul	
BAT_21.4	A/B	Maternity	None; SI	None	G(S)	-	SB
	C/D	Maternity	None; SI	None	G(S)	-	SB
	E	Rocket	None; SI	None	G(S)	-	-
	F	Rocket	None; SI	None	G(S)	-	-
BAT_134	A/B	Maternity	None; SI	None	G(S)	-	-
	C/D	Maternity	None; SI	None	G(M)	-	SB
	E	Rocket	None; SI	None	G(S)	-	SB
	F	Rocket	None; SI	G(S)	G(S)	-	-
BAT_153	A/B	Maternity	None; SI	None	G(S)	-	-
	C/D	Maternity	None; SI	None	G(S)	-	-
	E	Rocket	None; SI	None	G(S)	-	-
	F	Rocket	None; SI	None	G(M)	-	-
BAT_246	A/B	Maternity	None; SI	G(S)	G(S)	-	-
	C/D	Maternity	None; SI	None	G(S)	-	-
	E	Rocket	None; SI	None	G(S)	-	-
	F	Rocket	None; SI	G(S); VI(1)	G(M)	-	-
BAT_247	A/B	Maternity	None; SI	None	G(S)	-	TL
	C/D	Maternity	None; SI	None	G(S)	-	SB
	E	Rocket	None; SI	None	G(M)	-	SB; TL
	F	Rocket	None; SI	None	G(S)	-	SB; TL
BAT_254	A/B	Maternity	None; SI	None	G(S)	-	-
	C/D	Maternity	None; SI	None	None	-	-
	E	Rocket	None; SI	None	None	-	SB; TL(2)
	F	Rocket	None; SI	None	G(M)	-	TL(2)
BAT_258	A/B	Maternity	None; SI	G(S); VI(1)	G(M)	VI(1)	-
	C/D	Maternity	None; SI	G(S); VI(1)	G(M)	None	TL(4)
	E	Rocket	None; SI	G(S)	G(S)	VI(1)	-
	F	Rocket	None; SI	G(M)	G(S)	None	-
BAT_258NE	A/B	Maternity	None; SI	G(S)	G(S)	-	-
	C/D	Maternity	None; SI	G(M); VI(1)	G(S)	-	-
	E	Rocket	None; SI	G(M)	G(M)	-	-
	F	Rocket	None; SI	G(M)	G(M)	-	-
BAT_272.2N	A/B	Maternity	None; SI	None	G(S)	-	TL
	C/D	Maternity	None; SI	None	None	-	TL
	E	Rocket	None; SI	None	G(S)	-	-
	F	Rocket	None; SI	G(S)	None	-	TL
BAT_272.2S	A/B	Maternity	None; SI	G(M); VI(2)	G(L)	None	-
	C/D	Maternity	None; SI	G(M)	None	VI(1)	SB
	E	Rocket	None; SI	G(M)	G(L)	VI(1)	-
	F	Rocket	None; SI	G(M)	None	None	SB

None – None observed; G(S/M/L) – Guano (quantity: Small/ Moderate/ Large); VI(#) – Visually observed (number observed); AO – Audibly observed; M(#) – Mortality (number collected); SD – Guano Screen Damaged; SI – Screen installed; SR; Screen repaired; TL – Temperature logger(# installed, if >1)

Table C2: Bat Occupancy and Emergence Survey Results 2020

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			19-22 May, 5, 17 Jun	17-23Jul	16-19 Sep	20, 22-23, 29, 31 Jul	
BAT_21.4	A/B	Maternity	None	G(S); VI(2); SD	G(S)	-	Screen to be Replaced 2021
	C/D	Maternity	None	G(S); SD	G(S)	-	Screen to be Replaced 2021
	E	Rocket	None	None; SD	G(S)	-	Screen to be Replaced 2021
	F	Rocket	None	None; SD	G(S)	-	Screen to be Replaced 2021
BAT_48	A/B	Maternity	In-accessible	None; SI	G(S)	-	
	C/D	Maternity	In-accessible	None; SI	None	-	
	E	Rocket	In-accessible	None; SI	None	-	
	F	Rocket	In-accessible	None; SI	None	-	
BAT_53	A/B	Maternity	In-accessible	None; SI	G(S)	-	Box B roof shingle fell off
	C/D	Maternity	In-accessible	None; SI	None	-	
	E	Rocket	In-accessible	None; SI	G(S)	-	
	F	Rocket	In-accessible	None; SI	G(S)	-	
BAT_55	A/B	Maternity	In-accessible	None; SI	None	-	
	C/D	Maternity	In-accessible	None; SI	None	-	
	E	Rocket	In-accessible	None; SI	None	-	
	F	Rocket	In-accessible	None; SI	None	-	
BAT_62	A/B	Maternity	In-accessible	None; SI	None	-	SB
	C/D	Maternity	In-accessible	None; SI	None	-	SB
	E	Rocket	In-accessible	None; SI	G(S)	-	SB
	F	Rocket	In-accessible	None; SI	None	-	SB
BAT_82.1	A/B	Maternity	None; SI	None	None	-	Screen to be Replaced 2021
	C/D	Maternity	None; SI	None	None	-	Screen to be Replaced 2021
	E	Rocket	None; SI	G(S)	G(S)	-	Screen to be Replaced 2021
	F	Rocket	None; SI	G(S)	None	-	Screen to be Replaced 2021
BAT_134	A/B	Maternity	None	None	G(S)	-	
	C/D	Maternity	None	G(S); VI(1)	G(S)	-	
	E	Rocket	None	G(S)	G(S)	-	TL
	F	Rocket	G(S)	G(S)	G(M)	-	TL
BAT_144	A/B	Maternity	None; SI	G(S); VI(2)	G(S)	-	
	C/D	Maternity	None; SI	None	None	-	
	E	Rocket	None; SI	None	None	-	
	F	Rocket	None; SI	None	None	-	

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			19-22 May, 5, 17 Jun	17-23Jul	16-19 Sep	20, 22-23, 29, 31 Jul	
BAT_145	A/B	Maternity	None; SI	None	G(S)	-	
	C/D	Maternity	None; SI	None	G(S)	-	
	E	Rocket	None; SI	None	G(S)	-	
	F	Rocket	None; SI	None	G(S)	-	
BAT_153	A/B	Maternity	None	G(S); VI(2)	G(S)	-	
	C/D	Maternity	G(M); VI(1)	G(S)	G(S)	-	
	E	Rocket	None	G(S)	G(S)	VI(3)	
	F	Rocket	G(S)	G(S)	G(S)	VI(2)	
BAT_217E	A/B	Maternity	None; SI	None	None	-	
	C/D	Maternity	None; SI	None	None	-	
	E	Rocket	None; SI	G(S); VI(1)	None	-	
	F	Rocket	None; SI	None	G(S)	-	
BAT_217W	A/B	Maternity	None; SI	None; SD	G(S)	-	
	C/D	Maternity	None; SI	None; SD	None	-	
	E	Rocket	None; SI	None; SD	None; VI(1)	-	SB
	F	Rocket	None; SI	None; SD	G(S)	-	SB
BAT_246	A/B	Maternity	None	None	None	-	-
	C/D	Maternity	G(S)	None	G(S)	-	-
	E	Rocket	None	None	G(S)	-	-
	F	Rocket	G(S)	G(M)	G(M)	-	Damage to SW corner of roof shingle (July)
BAT_247	A/B	Maternity	None	G(S)	None	-	
	C/D	Maternity	None	G(S); VI(1)	G(S); VI(1)	-	SB
	E	Rocket	None	G(S)	G(S)	-	SB
	F	Rocket	None	G(M)	G(S)	-	SB
BAT_254	A/B	Maternity	None	G(M); VI(2)	G(S)	-	TL
	C/D	Maternity	None	G(S); VI(2)	G(S)	-	TL
	E	Rocket	None	G(S)	G(S)	-	SB
	F	Rocket	None	G(S)	G(S)	-	
BAT_258	A/B	Maternity	None	G(S)	G(S)	-	-
	C/D	Maternity	None	G(S)	G(S)	-	-
	E	Rocket	G(S)	G(S)	G(M)	-	-
	F	Rocket	G(S)	G(S); VI(2)	G(M)	-	-
BAT_258NE	A/B	Maternity	None	G(M); VI(2)	G(S)	VI(1)	-
	C/D	Maternity	None	G(M); VI(2)	G(S)	VI(2)	-
	E	Rocket	G(M)	G(M)	G(M)	None	-
	F	Rocket	G(M)	G(M); VI(6)	G(S)	VI(1)	-
BAT_272.2N	A/B	Maternity	G(M)	G(S); VI(1); SD	G(S)	VI(18)	TL; Screen to be Replaced 2021
	C/D	Maternity	None	G(S); VI(1); SD	None	None	TL; Screen to be Replaced 2021

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			19-22 May, 5, 17 Jun	17-23Jul	16-19 Sep	20, 22-23, 29, 31 Jul	
	E	Rocket	G(M)	G(S); SD	G(S)	VI(6)	TL; Screen to be Replaced 2021
	F	Rocket	G(S); AO	G(S); VI(1); SD	None	VI(2)	TL; Screen to be Replaced 2021
BAT_272.2S	A/B	Maternity	None	G(S)	G(M)	VI(1)	Screen to be Replaced 2021
	C/D	Maternity	None	G(L); AO	None	VI(1)	Screen to be Replaced 2021
	E	Rocket	G(S)	G(M)	G(L)	VI(6)	Screen to be Replaced 2021
	F	Rocket	G(S)	G(L)	G(M)	VI(2)	Screen to be Replaced 2021
BAT_330.2	A/B	Maternity	SI; G(S)	G(M); VI(3)	G(M)	VI(1)	TL
	C/D	Maternity	None; SI	G(S)	G(M); VI(1)	VI(1)	TL
	E	Rocket	SI; G(S)	G(S)	G(L)	VI(3)	TL
	Condo	Condo	None	G(S)	G(S)	VI(1)	TL(2)

None – None observed; G(S/M/L) – Guano (quantity: Small/ Moderate/ Large); VI(#) – Visually observed (number observed); AO – Audibly observed; M(#) – Mortality (number collected); SD – Guano Screen Damaged; SI – Screen installed; SR; Screen repaired; TL – Temperature logger(# installed, if >1)

Table C3: Bat Occupancy and Emergence Survey Results 2021

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			14-25 May	12-15 Jul	13-15 Sep, 14 Oct	14, 28-31 July	
BAT_21.4	A/B	Maternity	G(M)	G(S); VI(1)	G(M)	-	Robust screens installed May
	C/D	Maternity	None	G(M)	G(S)	-	Robust screens installed May
	E	Rocket	G(S)	G(S)	G(M)	-	Robust screens installed May
	F	Rocket	G(S)	G(S)	G(S)	-	Robust screens installed May
BAT_48	A/B	Maternity	None	Not visited	G(S)	-	-
	C/D	Maternity	None	Not visited	G(S)	-	-
	E	Rocket	None	Not visited	None	-	Screen damaged
	F	Rocket	G(S)	Not visited	G(S)	-	-
BAT_53	A/B	Maternity	G(S)	Not visited	G(S)	-	TL; Box B roof shingle missing
	C/D	Maternity	None	Not visited	None	-	-
	E	Rocket	None	Not visited	None	-	TL; Screen frame destroyed – will need to be replaced 2022
	F	Rocket	None	Not visited	None	-	-
BAT_55	A/B	Maternity	None	Not visited	None	-	-
	C/D	Maternity	None	Not visited	None	-	TL
	E	Rocket	None	Not visited	G(S)	-	TL
	F	Rocket	None	Not visited	None	-	-
BAT_62	A/B	Maternity	None	Not visited	G(M)	-	-
	C/D	Maternity	G(S); VI(1)	Not visited	G(S)	-	-
	E	Rocket	None	Not visited	G(S)	-	-
	F	Rocket	G(S)	Not visited	G(S)	-	-
BAT_82.1	A/B	Maternity	G(S)	None	G(S)	-	Robust screens installed May; TL
	C/D	Maternity	None	None	G(M)	-	Robust screens installed May; TL
	E	Rocket	G(S)	G(S)	G(M)	-	Robust screens installed May; superficial paint damage
	F	Rocket	G(S)	G(M)	G(M)	-	Robust screens installed May

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			14-25 May	12-15 Jul	13-15 Sep, 14 Oct	14, 28-31 July	
BAT_134	A/B	Maternity	None	G(S); VI(1)	G(S)	-	-
	C/D	Maternity	G(S)	G(S); VI(1)	None	-	-
	E	Rocket	None	G(S)	G(S)	-	-
	F	Rocket	None	G(S)	G(S)	-	-
BAT_144	A/B	Maternity	None	None	G(S)	-	-
	C/D	Maternity	None	None	G(S)	-	-
	E	Rocket	None	None	G(S)	-	-
	F	Rocket	None	None	G(S)	-	-
BAT_145	A/B	Maternity	G(S)	G(S)	G(S)	-	-
	C/D	Maternity	None	G(M)	G(M); VI(1)	-	-
	E	Rocket	G(S)	None	G(S)	-	-
	F	Rocket	G(S); VI(1)	G(S)	G(L)	-	-
	G	Maternity	G(S)	None	None		TL
BAT_153	A/B	Maternity	G(S)	G(S)	G(S)	-	-
	C/D	Maternity	G(S)	G(S); VI(1)	G(S)	-	-
	E	Rocket	G(M); VI(2)	G(L); VI(2)	G(S)	VI(6)	Screen frame damaged
	F	Rocket	G(S); VI(2)	G(M); VI(1)	G(S)	VI(4)	Screen frame damaged – will need to be replaced in 2022
BAT_217E	A/B	Maternity	None	None	G(S)	-	-
	C/D	Maternity	None	None	G(S)	-	-
	E	Rocket	None	None	G(S)	-	-
	F	Rocket	None	None	G(S)	-	-
BAT_217W	A/B	Maternity	G(S)	None	G(S)	-	-
	C/D	Maternity	None	None	G(S)	-	-
	E	Rocket	G(S)	G(S)	G(S)	-	-
	F	Rocket	G(S)	G(S)	G(S)	-	-
BAT_246	A/B	Maternity	None	G(S)	G(S)	-	-
	C/D	Maternity	None	None	G(S)	-	-
	E	Rocket	None	None	None	-	-
	F	Rocket	None	G(M)	G(M)	-	Piece of roof shingle fell off
BAT_247	A/B	Maternity	None	G(S)	G(S)	-	-
	C/D	Maternity	G(S)	G(S); VI(1)	G(S)	-	-
	E	Rocket	G(S)	None	G(S)	-	-
	F	Rocket	None	G(S); VI(1)	G(S)	-	-

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			14-25 May	12-15 Jul	13-15 Sep, 14 Oct	14, 28-31 July	
BAT_254	A/B	Maternity	None	G(S)	G(S)	-	-
	C/D	Maternity	None	None	G(S)	-	-
	E	Rocket	None	G(S)	G(S)	-	-
	F	Rocket	G(S); VI(1)	None	G(S)	-	-
BAT_258	A/B	Maternity	None	None	G(S)	-	-
	C/D	Maternity	None	G(M); VI(1)	G(M); VI(1)	-	-
	E	Rocket	G(S)	G(S)	G(S); VI(1)	-	-
	F	Rocket	G(S)	G(S)	G(S); VI(1)	-	-
BAT_258NE	A/B	Maternity	G(S)	G(M); VI(1)	G(M); VI(1)	VI(2)	-
	C/D	Maternity	G(M); VI(1)	G(M); VI(7)	G(L); VI(2)	VI(9)	-
	E	Rocket	G(M)	G(M)	G(L); VI(3)	VI(2)	-
	F	Rocket	G(M); VI(3)	G(S); VI(1)	G(M)	VI(4)	-
BAT_272.2N	A/B	Maternity	G(S); VI(1)	G(L); VI(1)	G(L); VI(1)	VI(60)	Robust screens installed May; TL
	C/D	Maternity	None	G(M); VI(1)	G(L); VI(1)	VI(3)	Robust screens installed May; TL
	E	Rocket	None	G(M)	G(L)	VI(3)	Robust screens installed May; TL
	F	Rocket	None	G(L)	G(L); VI(1)	VI(30)	Robust screens installed May; TL
BAT_272.2S	A/B	Maternity	G(S)	G(M); VI(9)	G(L)	VI(9)	Robust screens installed May
	C/D	Maternity	G(S)	G(S)	G(L); VI(2)	VI(3)	Robust screens installed May
	E	Rocket	G(L)	G(L); VI(2)	G(L)	VI(73)	Robust screens installed May
	F	Rocket	G(M)	G(S); VI(2)	G(L)	VI(20)	Robust screens installed May
BAT_330.2	A/B	Maternity	None	G(M); VI(1)	G(M); VI(3)	VI(5)	-
	C/D	Maternity	None	G(S)	G(M); VI(1)	VI(5)	-
	E	Rocket	G(S)	G(M); VI(3)	G(M); VI(1)	VI(10)	-
	Condo	Condo	G(S)	None	G(S)	None Observed	TL(2)

None – None observed; G(S/M/L) – Guano (quantity: Small/ Moderate/ Large); VI(#) – Visually observed (number observed); AO – Audibly observed; SD – Guano Screen Damaged; SI – Screen installed; SR; Screen repaired; TL – Temperature logger(# installed, if >1)

Table 4: Bat Occupancy and Emergence Survey Results 2022

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			6-8, 20 May	18-21 Jul	26-28 Sep, 14 Oct	27-31 July	
BAT_21.4	A/B	Maternity	None	G(S); VI(1)	G(S)	-	-
	C/D	Maternity	None	G(M)	G(S)	-	-
	E	Rocket	None	G(S)	G(S)	-	-
	F	Rocket	None	G(S)	G(S)	-	-
BAT_48	A/B	Maternity	None	G(S)	Not visited	-	-
	C/D	Maternity	None	None	Not visited	-	-
	E	Rocket	None	None	Not visited	-	-
	F	Rocket	None	None	Not visited	-	SR
BAT_53	A/B	Maternity	None	G(S)	Not visited	-	-
	C/D	Maternity	None	G(S)	Not visited	-	-
	E	Rocket	None	G(S); VI(1)	Not visited	-	-
	F	Rocket	None	G(S); VI(1)	Not visited	-	-
BAT_55	A/B	Maternity	None	None	Not visited	-	-
	C/D	Maternity	None	None	Not visited	-	-
	E	Rocket	G(S)	None	Not visited	-	-
	F	Rocket	None	None	Not visited	-	SR
BAT_62	A/B	Maternity	(GS)	G(S)	Not visited	-	SR
	C/D	Maternity	G(S)	G(S); VI(1)	Not visited	-	SR
	E	Rocket	None	G(S); VI(1)	Not visited	-	
	F	Rocket	None	G(S); VI(1)	Not visited	-	
BAT_82.1	A/B	Maternity	None	G(S); VI(2)	G(S)	-	-
	C/D	Maternity	None	G(M); VI(2)	G(M)	-	-
	E	Rocket	G(S)	G(S)	G(S)	-	Superficial paint damage
	F	Rocket	G(M)	G(S)	G(S)	-	-
BAT_134	A/B	Maternity	G(S)	G(S); VI(1)	G(S)	-	-
	C/D	Maternity	None	None; VI(1)	None	-	SR
	E	Rocket	None	G(S); VI(1)	G(S)	-	-
	F	Rocket	None	G(S); VI(2)	G(S)	-	-
BAT_144	A/B	Maternity	None	None	G(S)	-	-
	C/D	Maternity	None	G(S)	G(S)	-	-
	E	Rocket	None	G(S)	G(S)	-	-
	F	Rocket	None	G(S)	G(S)	-	-

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			6-8, 20 May	18-21 Jul	26-28 Sep, 14 Oct	27-31 July	
BAT_145	A/B	Maternity	G(S)	G(M); VI(1)	G(S)	-	-
	C/D	Maternity	G(S)	G(L); VI(>45); M(2)	G(L)	VI(24)	TL
	E	Rocket	None	G(S)	G(S)	-	-
	F	Rocket	G(M); AO	G(L): VI(>15); M(1)	G(L)	VI(106)	TL
	G	Maternity	None	None	G(M)		-
BAT_153	A/B	Maternity	None	G(S); VI(2)	G(S)	-	-
	C/D	Maternity	None	G(S); VI(1)	G(S)	-	SR
	E	Rocket	G(S)	G(M); VI(1)	G(S)	-	SR
	F	Rocket	None	G(M); VI(4)	G(L)	-	Screen replaced in May; Repaired in September
BAT_217E	A/B	Maternity	None	G(S)	None	-	TL
	C/D	Maternity	None	G(S)	G(S)	-	TL
	E	Rocket	None	G(S)	None	-	-
	F	Rocket	None	G(S)	G(S)	-	-
BAT_217W	A/B	Maternity	None	G(S)	G(S)	-	TL
	C/D	Maternity	None	None; VI(1)	G(S)	-	TL
	E	Rocket	None	G(S)	G(S)	-	TL
	F	Rocket	None	G(S)	G(S)	-	-
BAT_246	A/B	Maternity	None	G(S)	None	-	SR
	C/D	Maternity	None	G(S)	G(S)	-	SR
	E	Rocket	None	None	None	-	SR
	F	Rocket	None	G(S)	G(S)	-	SR
BAT_247	A/B	Maternity	None	G(S); VI(1)	None	-	SR
	C/D	Maternity	None	None	None	-	SR
	E	Rocket	None	None	None	-	-
	F	Rocket	None	G(S)	None	-	SR
BAT_254	A/B	Maternity	None	G(S)	None	-	-
	C/D	Maternity	G(S)	None; VI(1)	G(S)	-	-
	E	Rocket	None	G(S); VI(1)	G(S)	-	-
	F	Rocket	G(S)	G(S)	G(S)	-	-

Site	Box	Box Type	Occupancy Survey			Emergence Count	Comments
			6-8, 20 May	18-21 Jul	26-28 Sep, 14 Oct	27-31 July	
BAT_258	A/B	Maternity	None	G(S); VI(2)	G(S)	-	-
	C/D	Maternity	G(S)	G(M); VI(2)	G(S)	-	-
	E	Rocket	None	G(S)	G(S)	-	-
	F	Rocket	G(S)	G(S)	G(S)	-	-
BAT_258NE	A/B	Maternity	G(S)	G(M); VI(4)	G(M); VI(1)	VI(4)	-
	C/D	Maternity	G(S)	G(L); VI(>18)	G(S); VI(1)	VI(1)	-
	E	Rocket	G(S)	G(L); VI(3)	None	VI(48)	-
	F	Rocket	G(M)	G(L); VI(2)	G(M)	VI(16)	-
BAT_272.2N	A/B	Maternity	G(S)	G(L); VI(>20); M(1)	G(L)	Severe weather – survey abandoned	-
	C/D	Maternity	G(S)	G(L); VI(>20); M(1)	G(M)	Severe weather – survey abandoned	-
	E	Rocket	G(M)	G(L)	G(M)	Severe weather – survey abandoned	-
	F	Rocket	G(M)	G(L); M(3)	G(S)	Severe weather – survey abandoned	-
BAT_272.2S	A/B	Maternity	G(S)	G(L); VI(>30)	G(L)	VI(14)	TL
	C/D	Maternity	G(S)	G(L); VI(>30); M(2)	G(M)	VI(1)	TL
	E	Rocket	G(L); AO	G(L); M(1)	G(L)	VI(4)	TL
	F	Rocket	G(M)	G(L)	G(L)	VI(5)	TL
BAT_330.2	A/B	Maternity	G(S)	G(L); VI(>12)	G(M)	VI(3)	-
	C/D	Maternity	None	G(M); VI(1)	G(M)	VI(4)	-
	E	Rocket	G(S)	G(L); VI(2)	G(L)	VI(6)	-
	Condo	Condo	G(S)	G(S)	G(S)	VI(2)	TL(2); Shingle found on the ground

None – None observed; G(S/M/L) – Guano (quantity: Small/ Moderate/ Large); VI(#) – Visually observed (number observed); AO – Audibly observed; M(#) – Mortality (number collected); SD – Guano Screen Damaged; SI – Screen installed; SR; Screen repaired; TL – Temperature logger(# installed, if >1)

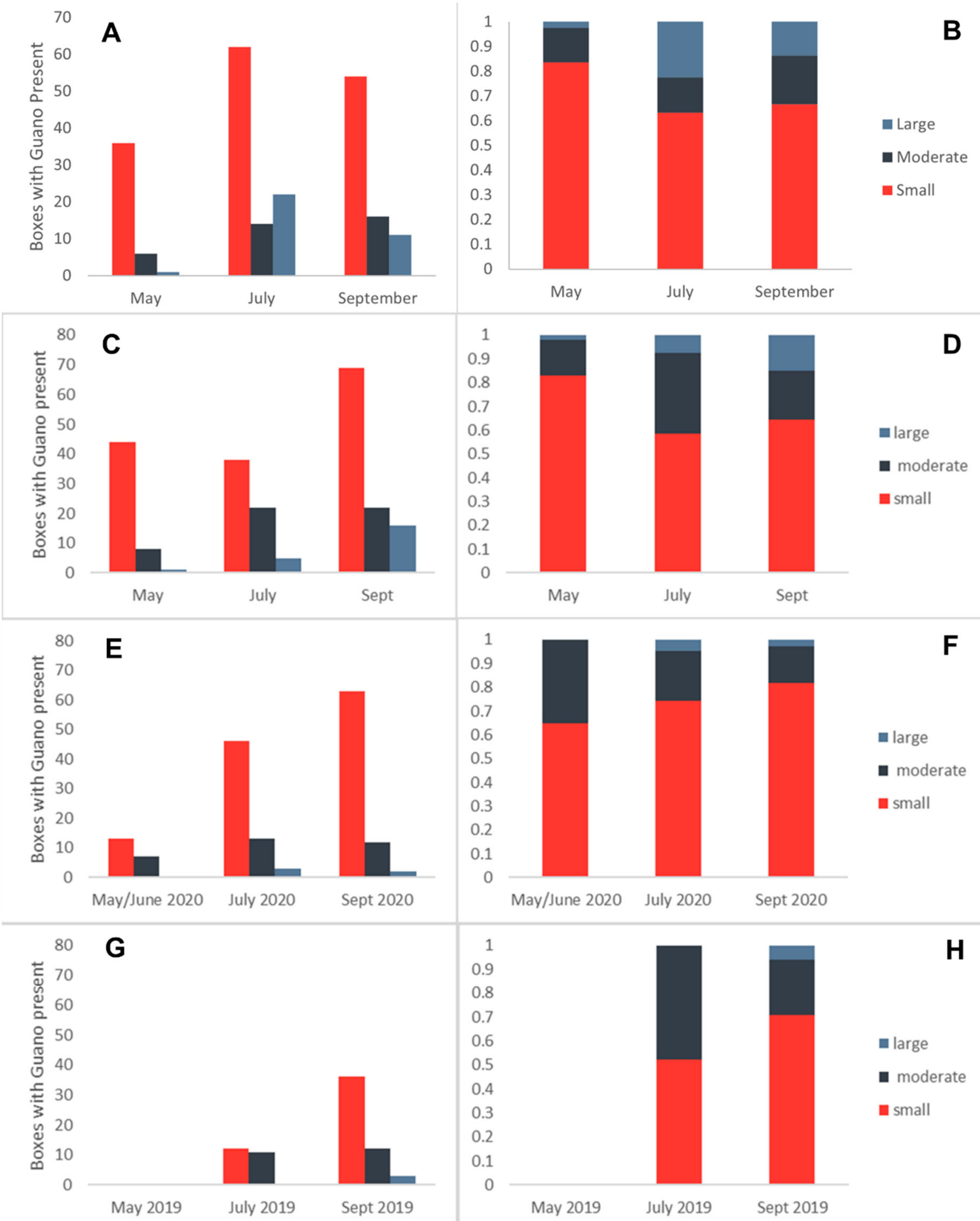

Figure C1: A) Number of bat boxes scored to have a 'Small', 'Moderate', or 'Large' quantity of guano in 2022, and B) proportion of boxes with guano scored as 'Small', 'Moderate', or 'Large' in 2022. C) Number of bat boxes and D) proportion of bat boxes with guano scored as 'Small', 'Moderate', or 'Large' in 2021. E) Number of bat boxes and F) proportion of bat boxes with guano scored as 'Small', 'Moderate', or 'Large' in 2020. G) Number of bat boxes and H) proportion of bat boxes with guano scored as 'Small', 'Moderate', or 'Large' in 2019.

wsp.com

Appendix 10. Artificial Snake Hibernacula Monitoring 2023 Annual Report

DRAFT

REPORT

Site C Wildlife Mitigation Structures

Snake Hibernacula Monitoring 2023

Submitted to:

BC Hydro

Attention: Brent Matsuda
111 West Georgia Street, 9th Floor
Vancouver, BC V6E 4G2

Submitted by:

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CA0006012.0622-003-R-RevA

22 December 2023

Distribution List

eCopy: BC Hydro

eCopy: WSP Canada Inc.

eCopy: Mike Sarell, Ophiuchus Consulting

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1.0 OVERVIEW

Two species of gartersnake are present in the Peace River Valley, western gartersnakes (*Thamnophis elegans*) and the common gartersnake (*T. sirtalis*). Both species are at risk of adverse effects due to the construction of the Site C Clean Energy Project (The Project; BC Hydro 2013). Additional information on the Project can be found in the *Site C Clean Energy Project Environmental Impact Statement, Volume 2, Section 14* (BC Hydro 2013), its accompanying Appendix R, *Terrestrial Wildlife and Vegetation Effects Assessment* (Hilton et al. 2013), and the *Site C Clean Energy Project Vegetation and Wildlife Mitigation and Monitoring Plan* (BC Hydro 2015a), and its Appendix J, *Garter Snake Mitigation and Monitoring Workplan* (BC Hydro 2015b).

To mitigate the loss of naturally occurring denning habitat in the Peace River Valley due to construction of the Project, BC Hydro has undertaken a program creating and monitoring artificial snake hibernacula (BC Hydro 2015b). BC Hydro contracted Blueberry River Enterprises (BRE) to install and monitor six bank-style snake hibernacula along the north side of the Peace River between Fort St. John and Hudson's Hope, BC (Figure 1, Appendix A: Figures A1-4. WSP Canada Inc. (WSP; previously Golder Associates Ltd. ([Golder])) was contracted by BRE to provide technical expertise related to snake ecology in support of the snake hibernacula monitoring program, and to lead related field work in conjunction with BRE representatives. Mike Sarell, of Ophiuchus Consulting, was subcontracted by WSP as a Snake Technical Advisor to provide expertise relevant to the mitigation and monitoring program. Snake hibernacula were installed in the summer of 2020 as detailed in the Snake Hibernacula Installation Report (Golder 2020). Hibernacula were monitored to assess potential snake use in the spring and summer of 2021 (Golder 2022) and 2022 (WSP 2023) completing BRE's monitoring contract. Subsequently a seventh artificial snake hibernaculum was installed by BC Hydro, the Ministry of Transportation and Infrastructure and Allnorth in July 2023 on the north side of the Peace River.

In 2023 BC Hydro contracted WSP to conduct an additional year of monitoring activities at the six previously installed hibernacula. In addition, BC Hydro requested WSP install a temperature probe at the seventh hibernacula that had been installed in July 2023. The requirements specific to 2023 snake hibernacula monitoring conducted by WSP are detailed in the Monitoring Agreement between BC Hydro and WSP Canada Inc. (BC Hydro Outline Agreement #4600001896). The initial six hibernacula were monitored in the spring and summer of 2023 to assess potential snake use. The new hibernacula installed in the summer of 2023 was not included in the 2023 monitoring program by WSP; however, incidental observations of snake presence were recorded during installation of the temperature logger and while monitoring other wildlife mitigation features (e.g., bat boxes) nearby.

This report documents the results of snake hibernacula monitoring activities undertaken by WSP in 2023.

2.0 BACKGROUND

The following details relating to installed snake hibernacula are summarized in Golder's 2020 installation report (Golder 2020) to provide background context and describe the configuration of the installed snake hibernacula.

The initial six snake hibernacula were installed in 2020 by Kalmar, Blueberry River Enterprises construction contractor, with guidance from the original *Gartersnake Mitigation and Monitoring Workplan* (Hilton et al. 2013) and advice and proposed field-refinement by Mike Sarell. The Scope of Services from BC Hydro (2017) outlined that three artificial bank-style hibernacula and three mound-style hibernacula be installed. Upon review of site conditions, and at the recommendation of Mike Sarell, all installed snake hibernacula were bank-style designs.

The original intent of installing mound-style hibernacula was largely a consequence of anticipated difficulties finding sufficient sites to locate an adequate number of preferred bank-style hibernacula at sloped sites (M.Sarell, pers. comm. 2020). Mound-style hibernacula, sited on level ground, have been used in England and eastern North America with success (Cresswell et al. 2008) but have not been tested in BC under more severe winter conditions (M.Sarell, pers. comm. 2020). For the six artificial hibernacula sites planned, the crew were able to find an adequate number of sloped sites for the preferred bank style hibernacula to be implemented. Known and suspected hibernacula in the Peace are typically situated on warm aspect slopes, and therefore this was determined to be a suitable model to follow for implementation of this Project (M.Sarell, pers. comm. 2020). The seventh installed hibernaculum by BC Hydro was similarly a bank style hibernaculum.

The locations of installed snake hibernacula are shown in Figure 1 and Appendix A (Figures A1-A-4), with installation details summarized in Table 1.

3.0 2023 MONITORING RESULTS

Monitoring activities in 2023 consisted of two rounds of site visits to assess occupancy, download internal and local ambient temperatures via temperature loggers at each of the initial six hibernaculum, replace batteries in the temperature loggers, as well as install a temperature logger at the new seventh snake hibernaculum (Snake Den 82.1; Site Photos; Appendix B). The following subsections provide summaries of these monitoring activities and results.

3.1 Occupancy Monitoring

Artificial dens were considered occupied if snakes were observed within 50 m of the entrance during at least one monitoring survey, or snake sign was detected within 10 m (M.Sarell, pers. comm., 2022). While this is not an absolute indication of occupancy, it does provide evidence that snakes have likely encountered an artificial den. Lack of snakes or snake sign does not confirm that occupancy has not occurred given that gartersnakes in the Peace appear to occur at low densities, making observations inconsistent (M.Sarell, pers. comm., 2022).

Two rounds of monitoring site visits occurred in 2023, with round one occurring on 6 and 8 of June, and round two occurring from the 27-29 of September. Additional opportunistic monitoring occurred when crews were near hibernaculum working on other projects (e.g., 15 July 2023 at Snake Den 82.1). Occupancy monitoring consisted of visual encounter surveys of the entrance and an approximately 50 m radius area surrounding the hibernacula to look for individual snakes or snake sign (e.g., tracks, faeces, shed skins). Surveys focused on areas with the highest probability of snake encounters (e.g., rock piles, logs, bare soil) while less effort was given to lower detection probability areas (e.g., uniform tall grass). Monitoring was also conducted further from the dens opportunistically while accessing the sites on foot.

Insert

Figure 1: Snake hibernacula installed on the north side of the future Site C reservoir in 2020 and 2023.

Table 1: Snake Hibernacula Installation Details

Snake Den	Installation Date	Easting / Northing (NAD 83) UTM Zone 10V	Distance to 'General Clearing Area'	Distance from trail/road (m)	Distance to drainage feature (m)	Nearby Habitat Features and Distance (m)	Nearby Installed Cover Features
21.4 (Dam View)	14 July 2020	626695, 6234126	65.0 m (River/Stream – Intermittent)	200.8 m (Road unclassified)	574.4 m (Eastern Reservoir Clearing)	▪ Forested gully – 100 m west ▪ Forested habitat – 30 m east	▪ 2 patio stones – 2 m east and 2 m west of entrance
48 (Wilder Creek)	15 July 2020	618630, 6233149	159.0 m (Wilder Creek River/Stream – Definite)	149.6 m (Road unclassified)	91.4 m (Eastern Reservoir Clearing)	▪ Wilder Creek valley – 150 m east ▪ Forested habitat – 50 m south	▪ 1 rock pile 3 m northeast of entrance ▪ 2 patio stones – 2 m east and 2 m west of entrance
82.1 (Cache Creek)	5 July 2023	610711, 6238160	N/A	11.9 m (Trail)	78.5 m (Eastern Reservoir Clearing)	▪ Forested habitat – 50 m east	▪ 2 patio stones – 2 m east and 2 m west of entrance
134 (Watson Slough)	16 July 2020	603820, 6234237	52.9 m (River/Stream – Intermittent)	187.5 m (Trail)	85.0 m (Middle Reservoir Clearing)	▪ Forested gully – 30 m southeast	▪ 1 patio stone at entrance with small rock pile ▪ 1 rock pile 3 m northeast of entrance
153 (Halfway River)	16 July 2020	596484, 6232690	58.7 m (Flow Connectors – Inferred)	222.8 m (Trail)	545.9 m (Middle Reservoir Clearing)	▪ Silt bluffs – 700 m west ▪ Forested habitat – 50 m north and west	▪ 2 patio stones at entrance with small rock pile
272.2 (Peck's)	17 July 2020	573017, 6216971	35.4 m (River/Stream – Definite)	105.9 m (Road unclassified)	54.7 m (Western Reservoir Clearing)	▪ Beaver lodge and dugout pond - 15 m east ▪ Forested habitat – 10 m north and south	▪ 1 patio stone with three large rocks at entrance
326 (Lynx Creek)	18 July 2020	571450, 6214558	106.3m (Lynx Creek River/Stream – Definite)	44.2 (Road unclassified)	118.6m (Western Reservoir Clearing)	▪ Partially buried vehicles - 30 m southeast	▪ 2 patio stones 1 m east and 1 m west of the entrance and small rock pile

No observations of snake presence, evidence of use, or snake encounters were recorded at snake hibernacula in 2023 (Table 2; Figure 2). Previously, evidence of occupation had been recorded at two hibernacula in 2022 which represented the first evidence of potential gartersnake use of the hibernacula to date (WSP 2022). While gartersnakes were observed in the immediate vicinity of Snake Den 326 (Lynx Creek) in 2021, these were likely individuals salvaged from the Hudson's Hope bank stabilization project that were released at this den and therefore could not be considered as evidence of natural occupation (Ecofor 2021). Snake observations attributed to each site between 2021 and 2023 occurred within 500 m of the hibernacula entrances. However, the full area was not comprehensively surveyed but included incidental observations while walking into the sites (Figure 2). The lack of snake evidence observed in 2023 could be influenced by altered timing of the surveys, as the survey timing was delayed until early June following WSP receiving a contract for the project. The second visit was conducted following the arrival of equipment required to replace the damaged temperature loggers discovered during the first site visit.

Table 2: 2023 Snake Hibernacula Observations

Snake Den	Date	Occupation Evidence Observed	Snakes observed	Comments
21.4 (Dam View)	8 June	No	No	Water found within temperature logger; no data retrieved
	29 Sept	No	No	A new temperature logger was deployed
48 (Wilder Creek)	29 Sept*	No	No	Batteries were dead upon arrival and replaced; temperature logger data downloaded; solar shield damaged and fixed
82.1 (Cache Creek)	15 July	No	No	Newly constructed den observed for the first time during other wildlife monitoring work
	29 Sept	No	No	Temperature logger and probes installed
134 (Watson Slough)	8 June	No	No	Temperature logger data were downloaded
	29 Sept	No	No	Batteries were replaced in temperature logger
153 (Halfway River)	8 June	No	No	Air temperature probe was snapped; minimal water was found within temperature logger; temperature logger data were downloaded
	28 Sept	No	No	Air temperature probe replaced; batteries replaced
272.2 (Peck's)	6 June	No	No	Water was found within the temperature logger; dried off in office; data were downloaded; temperature logger malfunctioned 18 July but began recording again 20 July, stopped recording 21 July 2022.
	27 Sept	No	No	New temperature logger deployed
326 (Lynx Creek)	6 June	No	No	Hibernacula temperature probe was snapped; water found within the temperature logger; dried off in office; data were downloaded, hibernacula temperature data stopped 15 August 2022, air temperature data stopped 20 March 2023
	27 Sept	No	No	Hibernacula temperature probe replaced; batteries were replaced

*Initial emergence survey was not possible due to access restrictions to the site due to BC Hydro land access permissions.

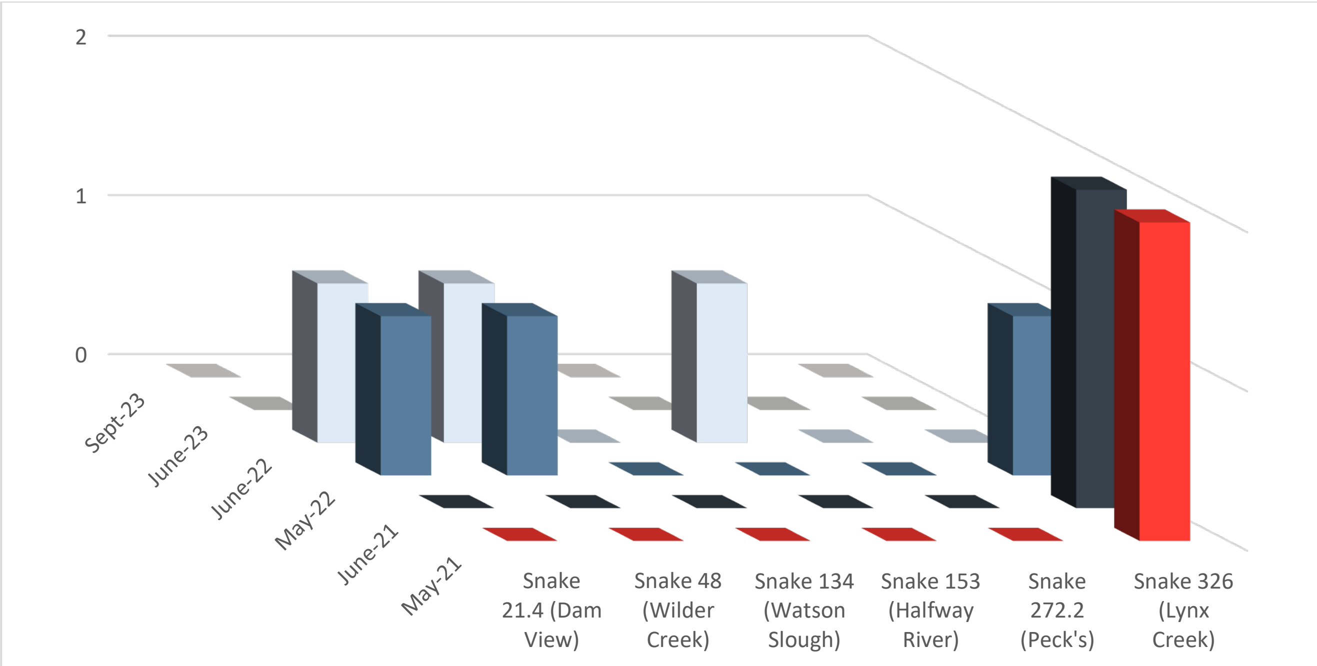

Figure 2: Number of snakes or snake sign observed within 500 m of hibernacula entrances (2021-2023).

3.1.1 Non-Target Species Observations

In 2021, amphibian species were found near the den entrances and in some cases were observed entering the dens during occupancy surveys, including long-toed salamander (*Ambystoma macrodactylum*), and western toad (*Anaxyrus boreas*; Golder 2022). These amphibians may have hibernated within the hibernacula given the time of year. In 2022 and 2023, no amphibians were recorded in the immediate vicinity of the hibernacula entrances.

3.1.2 Temperature Monitoring

The optimal temperature range for hibernating snakes is suspected to be between 4-7 °C in the Peace Region (M.Sarell, pers. comm. 2017), with unsuitable conditions presumed if temperatures within the hibernacula drop below 0 °C (Gregory 1971). However, gartersnakes have been observed to survive at least ‘short’ periods of subzero conditions, with 100% survival reported after 48 hrs at -1 °C in a population from central Wisconsin (Costanzo et al. 1988), and a 50% rate of survival after 10 hrs at -2.5 °C in a population from the interlakes region of Manitoba (Churchill and Storey 1992). Temperature monitoring was conducted at each hibernaculum to evaluate the range of temperatures present, particularly if temperatures decreased below 0 °C where conditions may become unsuitable for hibernating snakes.

Temperature monitoring was conducted via two temperature probes (HOBO USB Micro Station Logger with H21USB MicroStation Weatherproof datalogger [IP66]), which were deployed inside and outside of each hibernaculum to measure internal den temperature and local ambient temperature. The new HOBO USB Micro Station data loggers received in 2023 display “percentage of battery remaining” when accessed rather than battery levels being reported as “good” or “bad” on the older models that allowed for better assessment of battery life during the field surveys. The data logger is advertised as weatherproof and has an internal gasket sealing the perimeter, but as an added precaution loggers were placed within tupperware containers with drainage holes and buried flush with ground level. A small rock pile was created over the temperature logger to mark its location, prevent overgrowth, and to provide some protection. The ambient temperature probe was installed on the top of a post approximately 1 m above ground level within a solar radiation shield. The internal probe was housed in a half-inch PVC pipe which extended from ground level to the deepest part of the hibernacula, in presumably the most insulated portion of the den. All exposed wires were protected with chicken wire or were kept within the tupperware container also housing the data logger. Internal and external temperature was recorded hourly. Monitoring began during hibernacula installation in the fall of 2020 and has been continuous since. Data were first downloaded in May of 2021 and again in May of 2022 and June/September of 2023.

Temperature readings in some hibernacula fell below freezing over the winter of 2020/21 during an extreme cold weather period; therefore, modifications to hibernacula were completed during the second monitoring visit in 2021. These consisted of attempting to reduce the air flow at all hibernaculum entrances and further insulating select hibernaculum with additional earthen overburden to reduce internal heat loss. Expanding insulating foam and additional rocks were used to fill gaps in the hibernacula entrances, which were then reinforced with a concrete, sand, and mortar mix. It was also considered that lower temperature readings could have been a result of cold ambient air travelling down the PVC pipe containing the wiring for the temperature probe and possibly cooling the probe and into the den. PVC pipes housing the internal den temperature probes were therefore cut flush with ground level and approximately 40 cm lengths of foam were inserted in the tube to provide further insulation. It was acknowledged that this remedy would only work until the frost line extended to beyond the depth of the foam inserts. In addition, three hibernacula, Snake Den 326 (Lynx Creek), Snake Den 153 (Halfway River), and Snake Den 272.2 (Peck’s), had additional soil added on top, which was then seeded, to create additional insulation.

Unfortunately, several issues were encountered limiting the amount of data retrieved in 2023. During the first round of monitoring surveys, the local ambient temperature probe and its radiation shield at Snake Den 153 were found to be destroyed. A review of the data revealed that it was likely destroyed on 29 July 2022, when it started recording unrealistic temperature readings, resulting in lost ambient site temperature data for the winter period. A new ambient temperature probe was installed, and field repairs were completed on the damaged solar shield on 28 September 2023. The temperature probe in the den of Snake Den 326 was also found to be destroyed during field visits on 8 June 2023. A review of the data revealed that it was likely destroyed on 15 August 2022, when it started recording unrealistic temperature readings, resulting in lost den temperature data for the winter period. This probe was replaced on 27 September 2023. Upon review of both destroyed temperature probes, there were clear teeth marks on either side of where the wire snapped, likely indicating small mammal damage. The temperature loggers at Snake Dens 21.4, 272.2 and 326 were found with water inside. Data was salvaged from both dens 272.2 and 326. However, data recovered from 272.2 malfunctioned between 18 and 20 July 2022 before failing completely on 21 July 2022 for unknown reasons. Data could not be salvaged from Snake Den 21.4. This logger was replaced with a spare unit on 29 September 2023. In 2022, as per recommendations (WSP 2023), all batteries were replaced during the second round of monitoring, which lead to no known battery issues during 2023 monitoring period. Batteries within all loggers were replaced again and the boxes containing temperature loggers were adjusted to limit the chance of water buildup within them in September 2023.

During the winter of 2022/2023 minimum temperature readings within two hibernacula decreased below 0°C: Snake 48 (Wilder Creek), and Snake 134 (Watson Slough; Figure 3). Temperature readings fell below 0°C at Snake 48 (Wilder Creek) starting in early-March 2023 and rose above 0°C on 1 April 2023. At Snake 134 (Watson Slough) temperature readings fell below 0°C in late-February 2023 and did not rise above 0°C again until late-March 2023 (note that snakes would normally move toward the entrance of the den in early spring as the ambient and surface ground temperature rose above cooler temperatures at the back of the den). The coldest local ambient temperatures occurred on 19 to 23 December 2022, with temperatures ranging from -31.5°C to -39.0°C, while coldest internal temperature readings were experienced in March, dependant on location (Table 3; Figure 3). Notably, the two hibernacula that had the lowest temperature readings (Snake 48 and Snake 134) demonstrated the greatest sensitivity to external temperatures, and were the warmest during the summer of 2022, suggesting a lack of sufficient insulation at these two locations. The internal temperature readings of both hibernacula fell below 0°C for the same amount of time (26 days) over a similar time period. However, it should be emphasized that the internal probes could also have experienced cold air wash down the piping, which could have cooled the dens.

As reported in 2022, if the temperature readings accurately represented actual internal temperatures of the dens, and if these dens were successfully occupied without mortality, it is possible that snakes in the Peace Region can tolerate much longer periods of subzero conditions than previously reported (Costanzo et al. 1988, Churchill and Storey 1992). Gartersnake body temperature has been recorded as low as 0.5 °C during hibernation and immediately following spring emergence in Manitoba (Lutterschmidt et al, 2006) and in northern Alberta (McCartney et al, 1989), suggesting that populations in the northern extent of their range may have some resiliency to cold stress.

Table 3: Minimum Internal Temperatures and Days below 0°C Recorded at each Hibernaculum*

Snake Den	Minimum Internal Temperature	Date of Minimum Internal Temperature	Days below 0°C	Date Range below 0°C
Snake Den 21.4 (Dam view)	n/a	n/a	n/a	n/a
Snake 48 (Wilder Creek)	-0.76 °C	18-Mar-2023	26	05-Mar-2023 to 1-Apr-2023
Snake 134 (Watson Slough)	-1.04 °C	16-Mar to 19-Mar-2023	26	27-Feb-2023 to 24-Mar-2023
Snake Den 153 (Halfway River)	0.91 °C	22-Jan and 23-Jan-2023	0	n/a
Snake 272.2 (Peck’s)	n/a	n/a	n/a	n/a
Snake Den 326 (Lynx Creek)	n/a	n/a	n/a	n/a

*Snake Den 82.1 was not monitored for temperature in 2023 due to installation in summer 2023

Modifications to reduce cooling winter temperatures were conducted in 2021 at all hibernacula. Additional modifications (added soil cap) were performed at Snake 134 (Watson Slough) and Snake 48 (Wilder Creek) in 2022 as these dens still experienced temperatures falling below freezing for extended periods of time in the winter of 2021/2022. Data was unable to be gathered for Snake Den 21.4 due water damaging the temperature logger.

Both Snake 134 and Snake 48 continued to experience temperatures below freezing suggesting that additional modifications may be required (Table 3; Figure 3). However, both remained below freezing for shorter periods of time than previous years, (Snake 134: 26 days in 2022-23 vs 104 days in 2021-22; Snake 48: 26 days in 2022-23 vs 95 days in 2021-22).

A mixed-effects model was used to test for significant differences in minimum temperatures within each hibernaculum after the additional gaps were filled in 2021 and additional soil was added in 2022. The model had four fixed effects, including a three-way interaction – the interaction consisted of a spline of the daily minimum outside temperature at the hibernaculum, a spline of the seven-day rolling average of external minimum temperature, and the treatment recorded at each hibernaculum (control, patched, patch and soil). The additional effect was a spline of day of year to account for seasonal changes. The random effect was a random intercept of hibernacula by year, allowing to account for variability between the hibernacula between years.

The fitted model described varying trends of internal temperature relative to external temperature and the insulative treatment provided (Figure 4). The predicted model values show a trend where internal temperatures are higher, at each 10°C bin (0, -10, -20, -30°C) of the 7-day rolling average, in hibernacula that had holes patched along with the addition of extra soil. However, the difference was not significant (Control-Patched, p = 0.34; Control-Patch and Soil, p = 0.99; Patched-Patch and Soil, p = 0.49). The Patch and Soil treatment saw the warmest predicted temperatures during rolling averages of -30°C and the coolest during averages of -10°C, likely caused by a lag in the effect external temperature has on the hibernacula**.** The only time all values remained above freezing was when the seven-day rolling average remained at 0°C. This model showed to have high levels of autocorrelation suggesting that the p values may be lower than the relationship would suggest. However, the results indicate that there was no statistical significance in the change of internal temperature after the addition of added insulative measures. The lack of statistical significance could come from missing factors that may be influencing internal temperatures (i.e., snowpack, cold air wash down the piping for the temperature probes). Despite there being no statistical significance, the trend of the data, along with the reduction of days below 0°C, suggests that the insulative measure could have had a biologically significant effect on internal hibernacula temperatures.

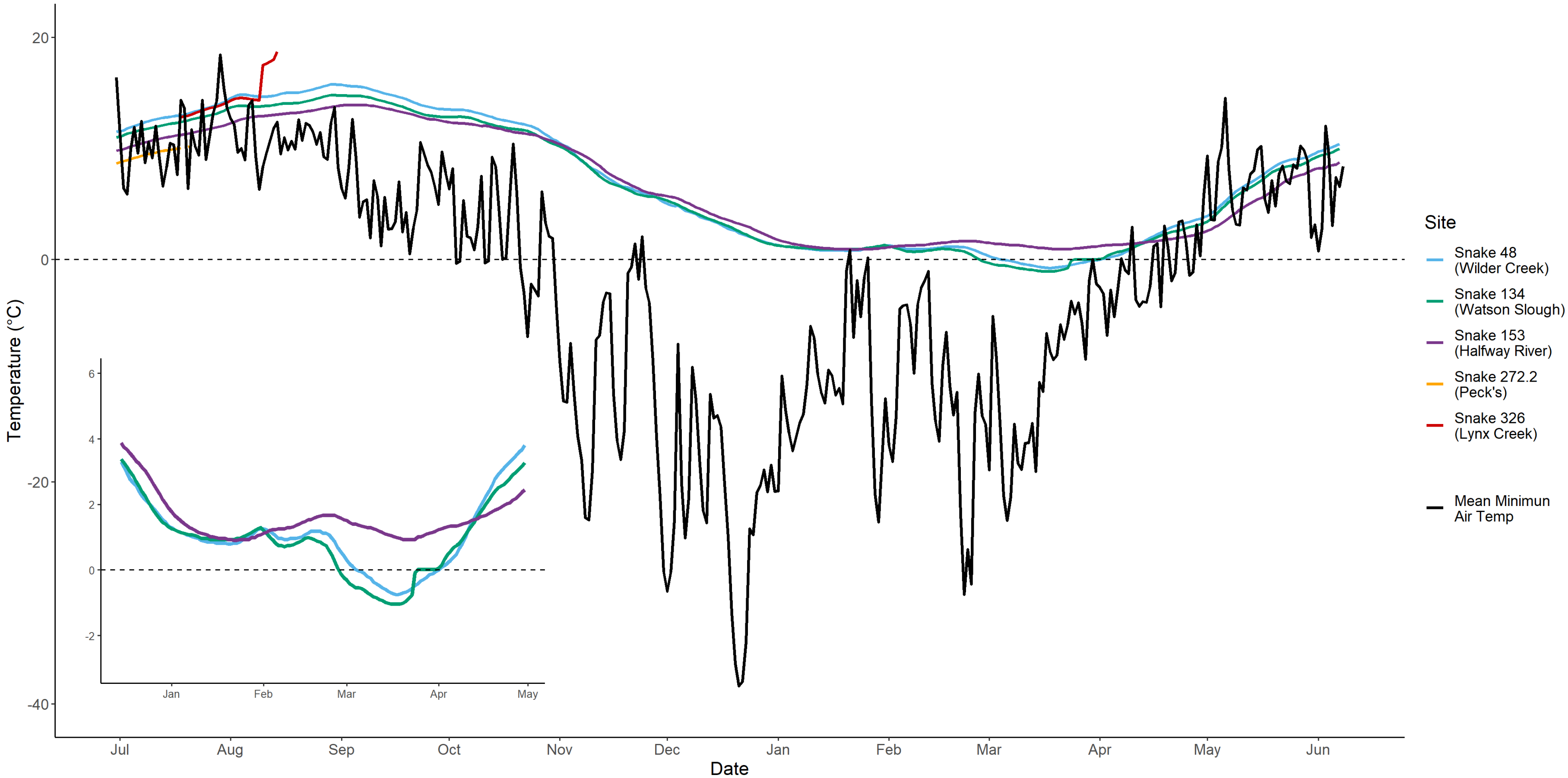

Figure 3: Daily minimum temperatures within hibernacula (coloured lines) and mean daily minimum ambient temperature recorded across sites (black) during the monitoring period, June 2022 to June 2023. A reference line (dashed) has been drawn at 0°C. Inset shows daily minimum hibernacula temperatures from 15 December 2022 to 1 May 2023.

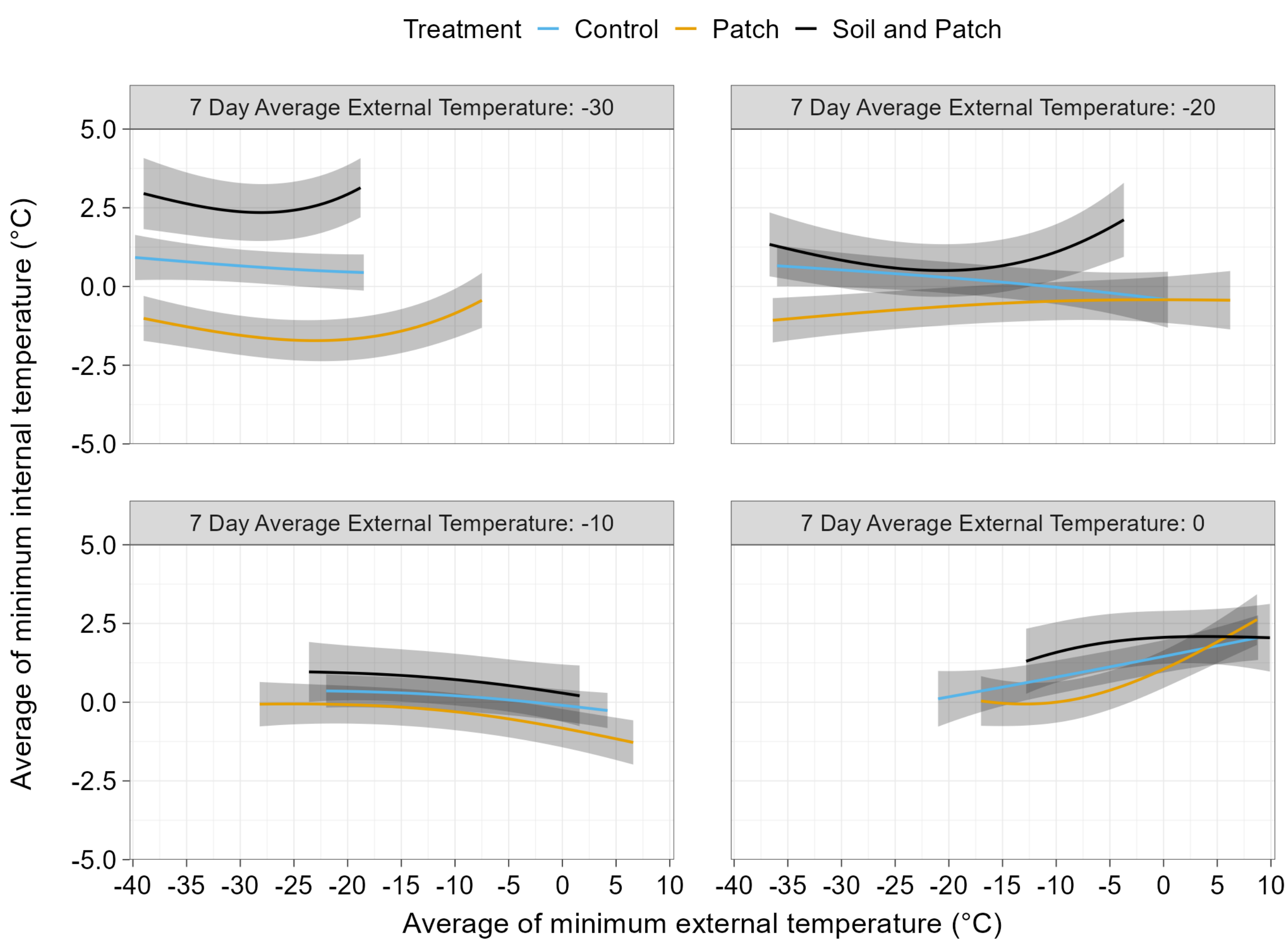

Figure 4: Fitted mixed-effects model for the relationship between minimum internal and external temperatures in relation to treatment applied. Shaded areas indicate the 95% confidence intervals for the modeled data.

4.0 FUTURE MONITORING RECOMMENDATIONS

Should BC Hydro continue with the monitoring of the installed hibernacula in 2024, the following activities are recommended at each snake hibernacula:

- Two occupancy surveys per year during spring emergence (April – June) with timing to be determined by weather trends each year. BC Hydro could consider adding a third survey to further increase the likelihood of encountering snakes during emergence allowing greater flexibility in the range of conditions surveys occur, and increasing the total search effort at each site. Based on observations of spring snake emergence in 2021 through 2023, it is anticipated that the first two weeks of May could be the most suitable timing for future monitoring visits.
- Assessment of the condition of each hibernaculum during future monitoring visits.
- Continued ongoing temperature monitoring via remote temperature loggers and data download during the spring emergence surveys. Based on challenges related to observed battery performance and damage to probes and loggers, we recommend continuing early fall site visits in 2024 to check that equipment remains functional just prior to the onset of winter conditions, as was completed in 2023.
- Reassessment of hibernacula thermal profiles and evaluation of the apparent effectiveness of additional soil caps to further insulate hibernacula. While analysis was conducted this year sensor-related malfunctions at multiple sites limited the development of a model demonstrating the influences of the insulation relation to soil depth and ambient temperature, and potentially compromised by the possible effects of cold air washing down the piping to the temperature sensor.

Other recommended actions or considerations should monitoring be conducted in 2024 and related to previously installed hibernacula are as follows:

- Recommend purchase of additional backup temperature logging sets proactively prior to spring emergence surveys for potential replacement prior to ongoing monitoring, as required.
- Recommend replacing housing containers of temperature loggers to reduce the potential for pooling water that may damage the loggers.
- Consider the use of infra-red imagery of the dens during different times of year to evaluate where heat loss is an issue and where insulation may best mitigate temperature loss.
- Recommend installing a total of two metres (40 cm already in place) of insulative foam down the temperature logger piping that houses the sensor wiring at all sites to reduce potential cold air washing at the placement of the sensor.
- Recommend filling gaps at the entrance of Snake Den 82.1 (Cache Creek) with expanding foam to limit air circulation, similar to that completed at the initial six hibernacula in 2022.
- Consideration for a rock or block retaining wall at the entrance of each den to reduce the potential for cold air flow through the entrance and adding more soil above the entrance to increase the insulation on the front slope of the den.

Should future den installation be undertaken the following should be considered:

- Future dens should consider installing temperature sensor piping horizontally through the entrance of the den to potentially further limit potential for cold air washing or moisture transference.
- For monitoring of depth of soil placement on top of dens, future dens should consider the installation of a 2x4 or similar structure with linear measurement (similar to a water stick gauge) placed vertically at the back of the den and sticking above the height of the soil fill to have a semi-permanent record of vertical and horizontal depths.

5.0 LIMITATIONS

This report has been prepared by WSP Canada Inc., for BC Hydro solely for the use of BC Hydro, in partial fulfilment of the terms and conditions of the Monitoring Agreement #686477. This report is limited to the field data, collected under the supervision of WSP, to assess occupancy of the snake hibernacula installed in 2020. Monitoring was not completed at the newly installed hibernaculum (Snake Den 82.1) due to the timing of installation. Although, a cursory survey of snake presence was conducted during the installation of the temperature probe at Snake Den 82.1.

The findings and conclusions documented in this report have been prepared for specific application to this Project and have been developed in a manner consistent with the level of care normally exercised by environmental professionals currently practicing under similar conditions in the jurisdiction. WSP makes no other warranty, expressed or implied.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. WSP accepts no responsibility for damages, if any suffered, by any third party as a result of decisions made or actions based on this report.

6.0 CLOSURE

We trust that this report provides sufficient information for your needs. If you have any questions, please do not hesitate to contact the undersigned.

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7.0 ACKNOWLEDGEMENT

We would like to extend our thanks to Mike Sarell (Ophiuchus Consulting) for his continued input and expertise in preparing this report and aiding with the monitoring program.

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APPENDIX A

Mapbook

APPENDIX B

Photos

Photo B1: Snake Den 21.4 (Dam View) entrance on 8 June 2023.

Photo B2: Snake Den 48 (Wilder Creek) entrance on 29 September 2023.

Photo B3: Snake Den 134 (Watson Slough) entrance on 8 June 2023.

Photo B4: Snake Den 153 (Halfway River) entrance on 8 June 2023.

Photo B5: Snake Den 326 (Lynx Creek) entrance on 6 June 2023.

Photo B6: Snake Den 272.2 (Peck's) entrance on 6 June 2023.

Photo B7: Snake Den 82.1 (Cache Creek) entrance on 29 September 2023.

Photo B8: Destroyed temperature probe at Snake Den 326 (Lynx Creek) on 6 June 2023.

Photo B9: Destroyed temperature probe and solar shield at Snake Den 153 (Halfway River) on 8 June 2023.

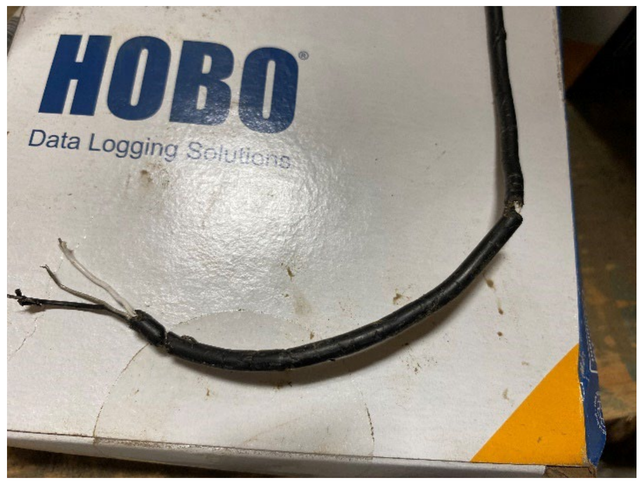

Photo B10: View of destroyed probe from Snake Den 153 (Halfway River) showing evidence of small mammal damage.

Photo B11: Water found within logger at Snake Den 21.4 (Dam View) on 8 June 2023.

Photo B12: Water found within logger at Snake Den 272.2 (Peck's) on 6 June 2023.

Photo B13: Example of soil cap added for additional insulation to Snake Den 134 on 24 October 2022.

Appendix 11. Cavity-Nesting Mitigation and Monitoring 2023 Annual Report

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Memorandum

Attention	Brent Matsuda, BC Hydro
From:	Ausenco Sustainability ULC
Subject:	Site C Clean Energy Project Cavity-Nesting Mitigation and Monitoring Program – 2023 Annual Report
Date	March 28, 2024
Document Ref:	107578-03

1.0 Introduction

BC Hydro assessed the potential effects of the Site C Clean Energy Project on Wildlife Resources in the Site C Environmental Impact Statement (EIS) using key species groups (BC Hydro 2013). Cavity-nesting bird species were assessed in the EIS as part of the migratory birds (passerines [songbirds], Northern Flicker (*Colaptes auratus*), and waterfowl) and raptors (hawks and owls) groups (BC Hydro 2016). In 2017, a mitigation and monitoring plan for cavity-nesting birds was developed with input from the Vegetation and Wildlife Technical Committee, which is comprised of representatives of the Canadian Wildlife Service, the BC Ministry of Environment and Climate Change Strategy and the BC Ministry of Forests, Lands, Natural Resources Operations and Rural Development.

The Cavity-Nesting Mitigation and Monitoring Program aims to mitigate habitat loss for cavity-nesting species associated with Site C reservoir vegetation clearing, and to monitor the effectiveness of that mitigation (BC Hydro 2018). Mitigating the impacts of habitat loss for cavity-nesting birds is focused on areas that will be retained (i.e., not cleared and not flooded) and currently have a low density of suitable trees for cavity-nesting species (i.e., structural stage 4 [pole-sapling] or 5 [young forest][1] habitats that have few large-diameter trees or snags). Mitigation of habitat loss will be achieved using different measures depending on the duration of the effects they are intended to mitigate (i.e., short-, medium-, or long-term). Nest box installation for cavity-nesting species provides short-term mitigation, the results of which are the focus of this memo.

[1] Structural Stage 4 (pole-sapling forest): Trees >10 m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous (usually >10–15 years old); older stagnated stands (up to 100 years old) are also included; self-thinning and vertical structure not yet evident in the canopy – this often occurs by age 30 in vigorous broadleaf stands, which are generally younger than coniferous stands at the same structural stage; time since disturbance is usually <40 years for normal forest succession; up to 100+ years for dense (5000–15 000+ stems per hectare) stagnant stands. Structural Stage 5 (young forest): Self-thinning has become evident and the forest canopy has begun differentiation into distinct layers (dominant, main canopy, and overtopped); vigorous growth and a more open stand than in the pole/sapling stage; time since disturbance is generally 40–80 years but may begin as early as age 30, depending on tree species and ecological conditions; from Resources Inventory Committee 1998).

2.0 Methods

2.1 Nest Box Construction

Cavity-nesting birds differ in their habitat requirements and selection of cavities. Therefore, a variety of nest box designs were constructed to mitigate impacts on nesting habitat for cavity-nesting birds due to activities associated with the Site C Clean Energy Project (**Photo 1**). Thirteen different nest box designs were constructed to accommodate 21 species of cavity-nesting birds, with some box designs intended to support multiple species (BC Hydro 2018).

Photo 1 Nest Box Designs Built for the Cavity-Nesting Mitigation and Monitoring Program

2.2 Nest Box Installation

The selection of sites followed specifications described in the Cavity Nesting Species Mitigation and Monitoring Program (BC Hydro 2018). The selection of habitat and placement of nest boxes was guided based on information from James (1984) and terrestrial ecosystem mapping data collected in 2016 along the periphery of the planned reservoir. Boxes were placed on lands owned or leased by BC Hydro or on Crown land, in areas outside of planned clearing boundaries, above the high-water mark, and in areas of suitable but suboptimal habitat (i.e., areas of suitable age class but with a low number of cavity trees).

Box installation was specifically focused on lower suitability habitat with a low proportion of potential cavity-nest trees (i.e., structural stages 4 to 5), but with the greatest potential to develop into more suitable habitat over the short term. **Photo 2** presents an example of an installed nest box design 'A', intended for Black-capped Chickadee (*Poecile atricapillus*), Boreal Chickadee (*P. hudsonicus*), Red-breasted Nuthatch (*Sitta canadensis*), White-breasted Nuthatch (*S. carolinensis*), House Wren (*Troglodytes aedon*), and Brown Creeper (*Certhia americana*).

Additional information based on literature and expert knowledge was also considered for the installation of nest boxes:

- proximity to a food source for all species (e.g., wetlands, water sources)
- bird distribution and abundance information from Site C baseline studies in the area
- known habitat associations
- appropriate nest heights (**Table 1**)
- density of nest boxes within an area (i.e., spacing between nest boxes) (**Table 1**).

Photo 2 Nest box design 'A'

Table 1 Installation Specifications for Nest Boxes Targeting Particular Bird Species

Species Group	Common Name	Scientific Name	Minimum Spacing Between Boxes (m)	Nest Box Height (m)
Passerines	Black-Capped Chickadee	*Poecile atricapillus*	150-200	1.5 - 4.5
	Boreal Chickadee	*Poecile hudsonicus*	150-200	1.5 - 3
	Brown Creeper	*Certhia americana*	150	1.0 - 10
	Red-Breasted Nuthatch	*Sitta canadensis*	50	1.5 - 4.5
	White-Breasted Nuthatch	*Sitta carolinensis*	300	1.5 - 6
	Tree Swallow	*Tachycineta bicolor*	10-30	1.5 - 1.8
	Violet-Green Swallow	*Tachycineta thalassina*	10-30	2.75 - 4.5
	House Wren	*Troglodytes aedon*	30	1.5 - 3
	Mountain Bluebird	*Sialia currucoides*	90	1.2 – 1.8
Waterfowl	Barrow's Goldeneye	*Bucephala islandica*	150-200	1.8 - 6
	Bufflehead	*Bucephala albeola*	50-150	1.5 - 3
	Common Goldeneye	*Bucephala clangula*	1,000	1.8 - 9
	Common Merganser	*Mergus merganser*	100	2.4 - 5.2
	Hooded Merganser	*Lophodytes cucullatus*	30	1.8 - 7.6
Raptors and Owls	Barred Owl	*Strix varia*	1,000	4.5 - 9
	Boreal Owl	*Aegolius funereus*	150	≥3
	Northern Saw-Whet Owl	*Aegolius acadicus*	400-500	≥3
	Northern Pygmy-Owl	*Glaucidium gnoma*	400-500	≥3
	Northern Hawk-Owl	*Surnia ulula*	500-700	≥3
	American Kestrel	*Falco sparverius*	500-800	3.5 – 6

2.3 Nest Box Monitoring and Maintenance

Nest box monitoring will continue biennially through the Site C Clean Energy Project construction and the first ten years of operations (**Appendix A**). Boxes installed in 2017 were monitored in 2020 (Hemmera Envirochem Inc. 2020) and again in 2022 and will be monitored every two years after that through the first 10 years of Project operations. Boxes installed in 2019 and 2020 were monitored in 2021 and again in 2023. This report summarizes the monitoring results for the boxes installed in 2019 and 2020.

In 2023, a qualified environmental professional conducted monitoring on the nest boxes installed in 2019 and 2020, following procedures that minimized disturbance to active nests. The breeding period information provided in Appendix B was used to time nest box visits, which were scheduled during stages when the likelihood of detecting use was highest. Specifically, visits were timed to coincide with nests at late incubation to early nestling stages, during which parents were more likely to feed their nestlings more frequently. However, as brood timing varies among and within species, timing surveys to coincide with nests containing older nestlings would increase the risk of arriving too late for direct observations of breeding activity for some nests. Therefore, a conservative estimate of the nesting window was applied to maximize the likelihood of observing active use and determining the species using each box.

During the monitoring work, surveyors approached the box discreetly, watching and listening for activity. When adults were attending a box, surveyors observed from a distance, recorded species, and attempted to determine stage (observations of food delivery and fecal sac removal confirmed nestling stage). If no use was evident from nest box observation, surveyors approached the nest box structure (tree or otherwise) and tapped lightly on it to elicit a response (Dudley and Saab 2003). If no bird appeared at the cavity entrance, a pole-mounted camera was used to examine the nest box contents. When nesting activity was documented but no adult birds were observed at the box, egg and nest characteristics (e.g., nesting material type, egg colour, shape, and size) were used to identify, where possible, the species or genus occupying the box. For species with similar eggs and nests, it is only possible to identify to genus (e.g., Goldeneye species [*Bucephala* spp.]).

During each nest box visit surveyors recorded the following data electronically:

- date and time
- coordinates
- surveyors
- weather conditions
- nest box ID
- detection methods
- adult behaviour
- audible nestlings
- food delivery
- pole camera examination
- whether the box is being used
- species detected
- notes informing environmental context, such as disturbance in the area.

Nest boxes have a 10 to 15-year lifespan with regular maintenance. Nest boxes in need of repair (e.g. damaged or fallen boxes, loose lids or covers) were flagged during the monitoring season in 2023 and repaired during the monitoring period if feasible (e.g. box not occupied and salvageable). Maintenance and repair included replacing nesting material with wood shavings if necessary and performing any replacement or repair of damaged boxes.

Some nest boxes have been deactivated to prevent them from being used if there was potential for other BC Hydro activities (e.g., clearing) disturbing nesting birds. Boxes were deactivated by first ensuring that the box was vacant and then installing a piece of wood to block the entrance hole.

3.0 Results

3.1 Nest Box Installation

Between 2017 and 2020, 268 nest boxes were installed on trees and structures on BC Hydro-owned and managed lands, and on private lands where permission was granted (**Table 2**, **Figure 1**). Twenty-one boxes have been installed near the lower reservoir, 78 near the eastern reservoir, 38 near the middle reservoir and 131 near the western reservoir.

Ninety-six nest boxes were installed in 2017 on the north side of the Peace River. An additional 171 nest boxes were installed from 2019 to 2020; 83 were installed in 2019 on the south side of the Peace River, and the remaining 88 were installed in spring 2020 on the north and south sides of the Peace River. The locations of the 2020 nest boxes were selected based on areas not covered in previous installations (2017 and 2019) and complementing the habitat and species assemblage within the proposed reservoir following the same criteria for habitat selection (see **Section 2.2**). Five boxes that had been damaged or removed were reinstalled in 2021.

Ten boxes of five different box types were installed in 2022 (**Photo 2**) on the south side of the river, including three E1, one G, one E2, three B3 and two F, for a total of 277 boxes installed in all years. **Table 2** summarizes the target species, habitat type and number of boxes of each design installed to date.

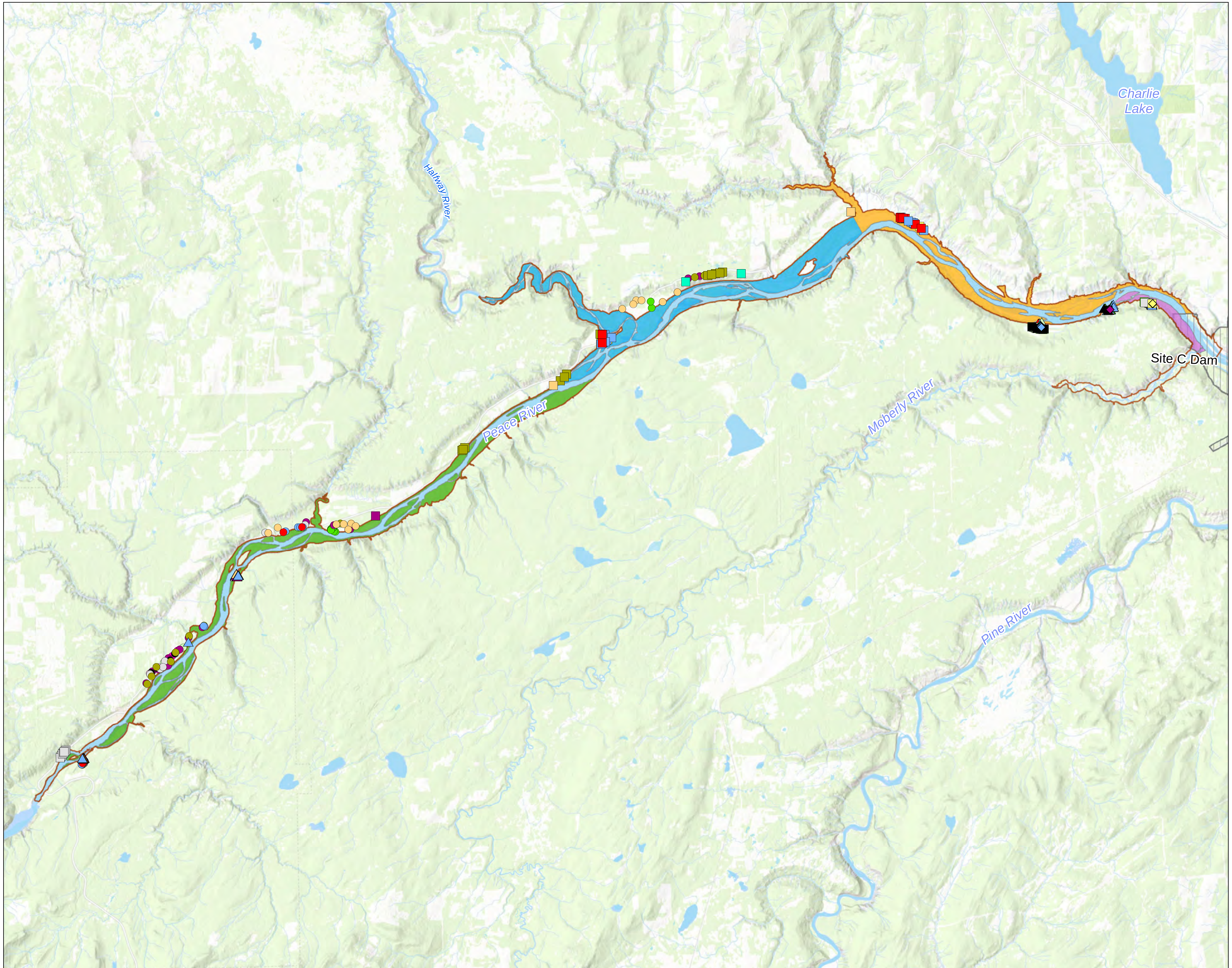
Table 2 Target Species, Habitat Preferences, and Total Number Nest Boxes Installed in 2017, 2019, 2020 and 2022

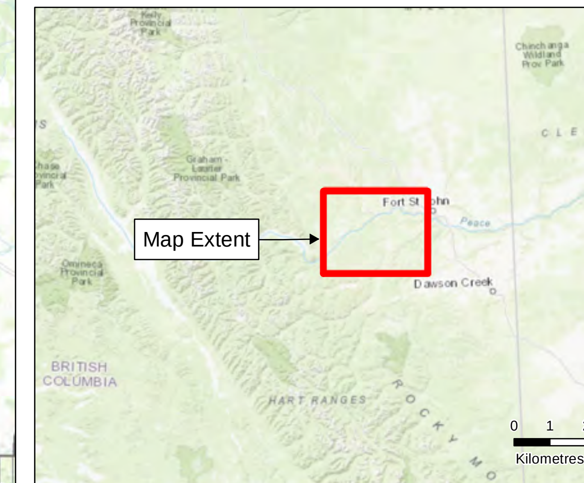
Species Group	Habitat Preference	Box Type	Species Supported	Number of Boxes Installed to Date
Passerine	• Use a variety of habitat types, from dry to wet forests and in most structural stages • Brown Creeper and Nuthatches prefer more mature forested habitats • Swallows use wetland and cultivated field habitat • Mountain Bluebirds require open field habitat	A / BC / B1	Black-Capped Chickadee Boreal Chickadee Red-Breasted Nuthatch White-Breasted Nuthatch House Wren Brown Creeper	44
		A2 / B2	Mountain Bluebird Tree Swallow Violet-Green Swallow	57
Waterfowl	• Need an unobstructed flight path from suitable forage habitat to nesting features	E1	Bufflehead	11
		F	Barrow's Goldeneye Common Goldeneye Hooded Merganser	50
		D / G	Common Merganser	19
Raptors and Owls	• Typically found in mesic to moist forests • smaller species found in younger forests • American Kestrel requires open field habitat	E2	Boreal Owl Northern Saw-Whet Owl	28
		E3	American Kestrel	17
		C	Northern Pygmy- Owl	26
		B3	Northern Hawk-Owl	23
		H	Barred Owl	2
			Total	**277**

Note: 264 boxes were proposed to be installed in total (BC Hydro 2018)

Site C Clean Energy Project
Peace River, BC

Nest Box Locations





Legend

- Dam Site
- 5 Year Beach Line
- Eastern Reservoir
- Lower Reservoir
- Middle Reservoir
- Western Reservoir

Nest Boxes - Year Installed

Type	2017	2019	2020	2022
A	●	▲	■	
A2	●	▲	■	
B1	●	▲	■	
B2	●	▲		
B3	●	▲	■	◆
BC	●	▲	■	
C	●	▲	■	
D			■	
E1	●		■	◆
E2	●	▲	■	◆
E3	●	▲	■	
F	●	▲	■	◆
G	●	▲	■	◆
H		▲	■	

Notes

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Sources

- Basemap: ESRI World Topographic Base

N

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0 2 4 6 8 10
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

107578-03	Production Date: Feb 8, 2024	Figure 1

Ausenco BC hydro

3.2 Monitoring and Maintenance of Nest Boxes Installed in Previous Years

Of the 144 boxes originally targeted for monitoring from June 14 June 19, 2023, 16 were deactivated or removed, due to construction work, destroyed due to inclement weather events, or bear activity, leaving a total of 128 nest boxes with potential for use that were targeted for monitoring (**Figure 2-1 to 2-18**).

Seventy nest boxes showed signs of use such as old nesting material, eggs or nestling present, or adults leaving the box (Appendix C). Eggs and nestlings were observed in 18 nest boxes. One of these boxes (E2-08) had Saw-Whet Owl (*Aegolius acadicus*) nestlings (**Photo 3, Figure 3**). American Kestrel (*Falco sparverius*) activity was detected at 16 nest boxes (**Photo 4, Figure 4**). One of the boxes (F-26) had two goldeneye eggs (**Figure 5**). Flying squirrels (*Glaucomys sabrinus*) were discovered using boxes E2-25 and F-24 (**Photo 5**) and a red squirrel (*Tamiasciurus hudsonicus*) was found inside the box F-46. Other signs of rodent use, such as droppings, tooth marks (**Photo 6**), or food caches, were observed at six additional boxes during monitoring. Two nest boxes (A-016 and F-19) were not inspected due to heavy wasp activity inside the box. Five boxes were damaged by bears (**Photo 7**), and one was previously deactivated (**Photo 8**) to safely conduct construction work in the area without potentially disturbing nesting birds. Several boxes had wasp nests inside which were removed when possible. See appendix C for detailed information on each box.

Photo 3 Saw-Whet Owls

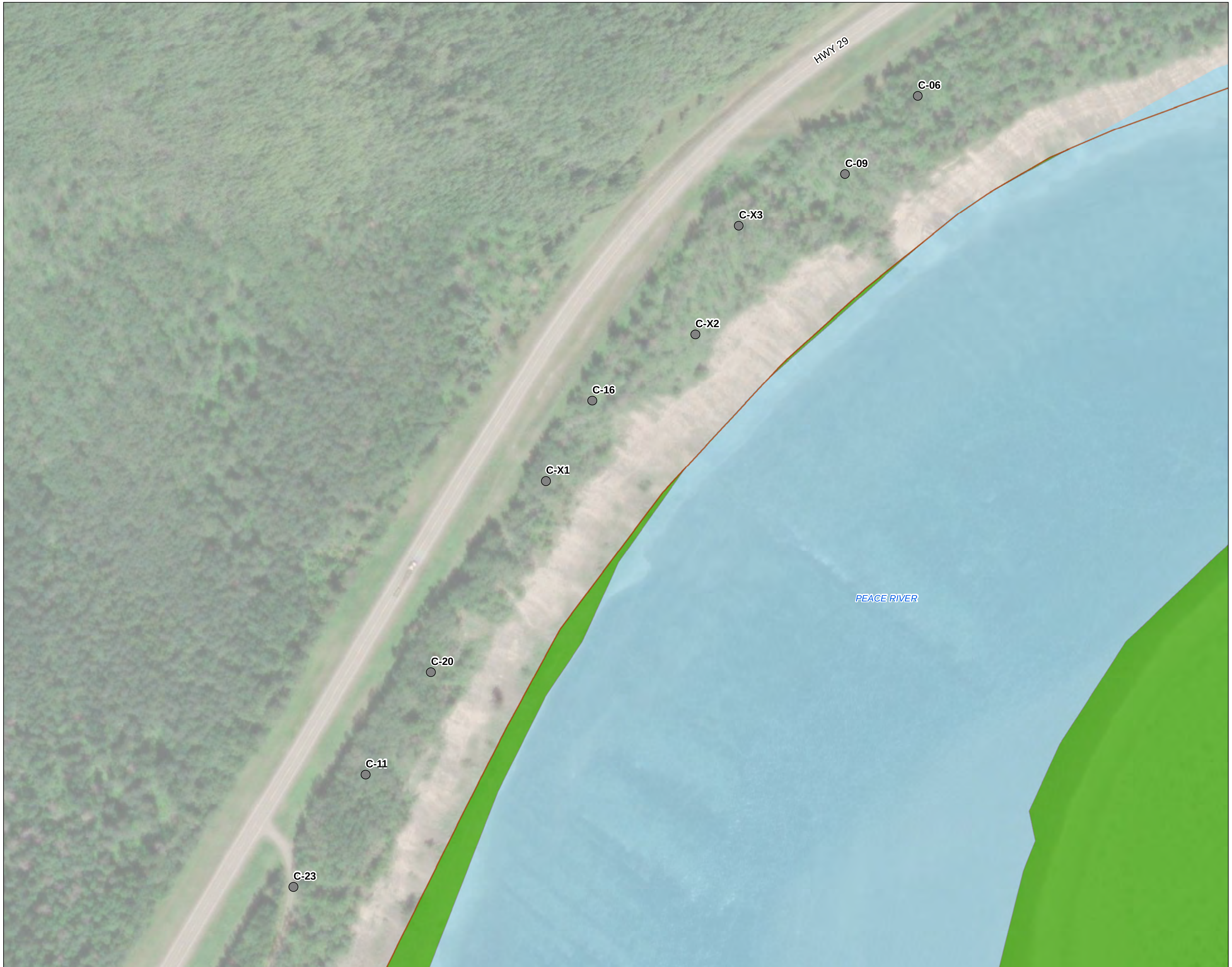
Photo 4 Dead American Kestrel

Photo 5 Flying squirrel

Photo 6 Rodent activity

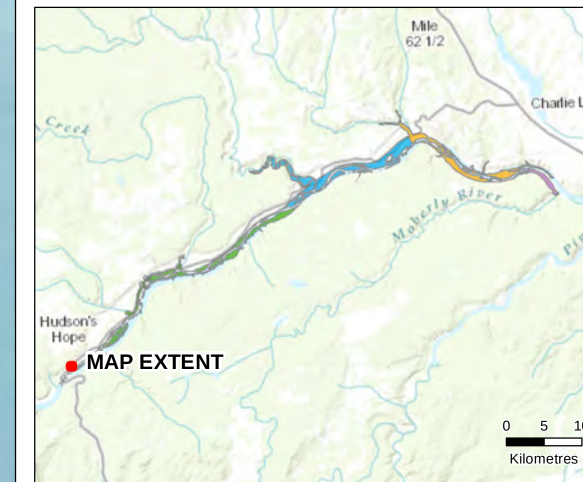
Photo 7 G-09 Nest box damaged by wildlife

Photo 8 Deactivated box



Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Not Used
- 5 Year Beach Line
- Western Reservoir
- Waterbody

Notes

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Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

N

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0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

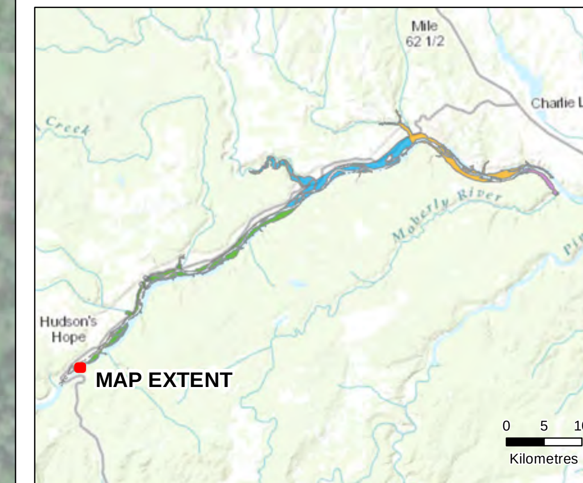
Page Size: 11" x 17"

989619-08	Production Date: Feb 8, 2024	Figure 2-1

Ausenco BChydro

Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used
- Nest Box - Not Used
- 5 Year Beach Line
- Western Reservoir
- Waterbody

Notes

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0 20 40 60 80 100
Metres

NAD 1983 UTM Zone 10N

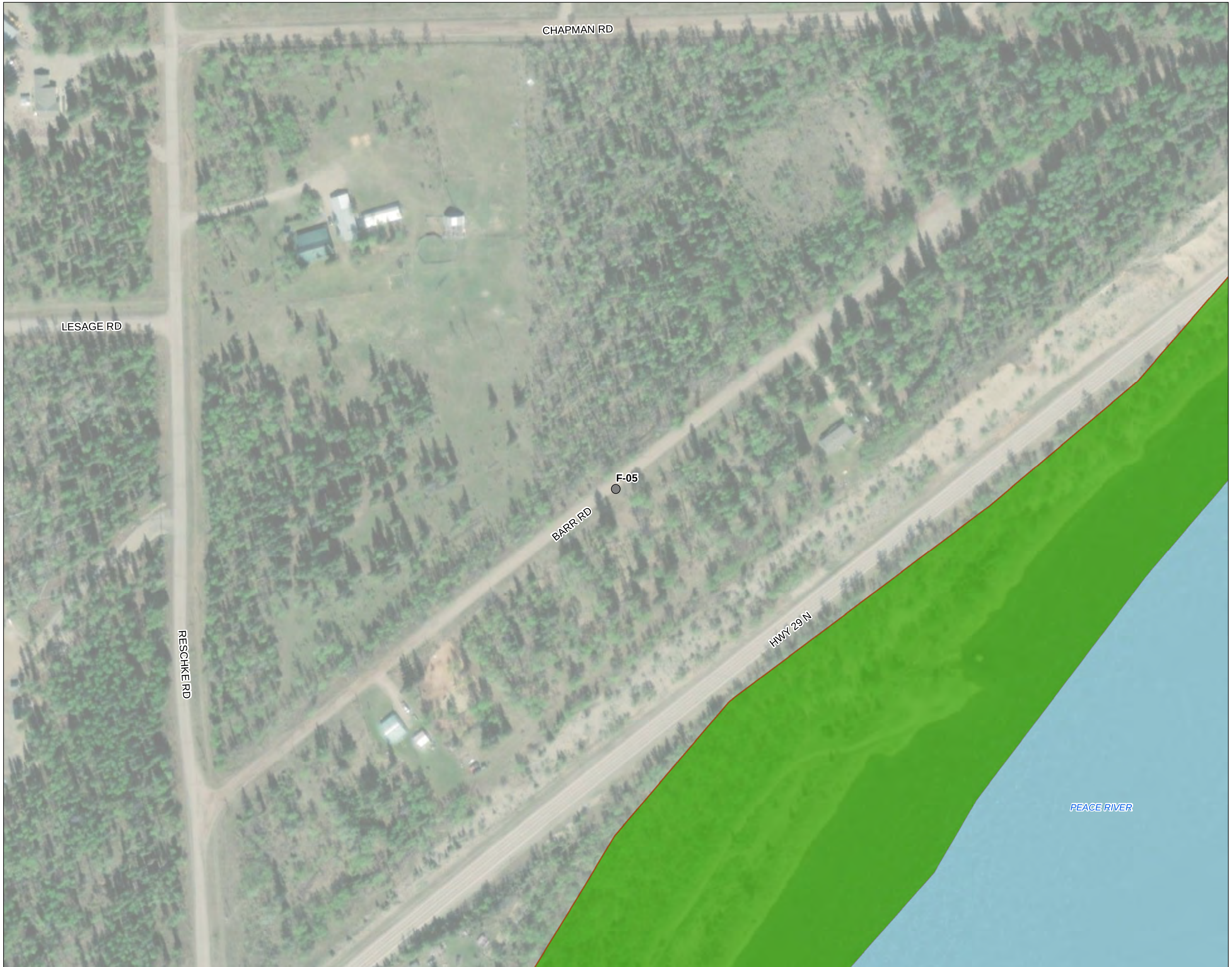
Page Size: 11" x 17"

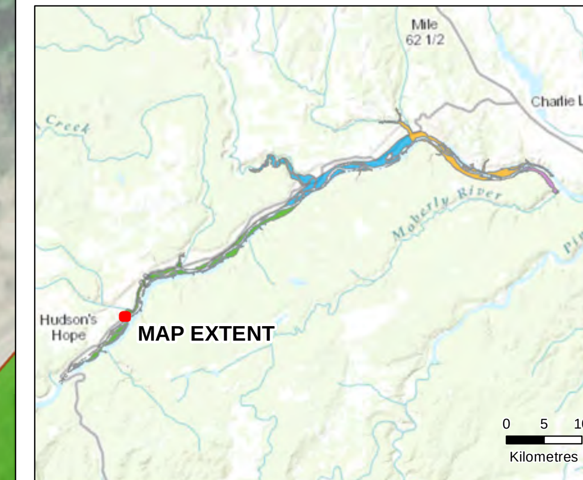
989619-08	Production Date: Feb 8, 2024	Figure 2-2

Ausenco BC hydro

Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes





Legend

- Nest Box - Not Used
- 5 Year Beach Line
- Western Reservoir
- Waterbody

Notes

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Sources

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- Inset Basemap: ESRI World Topographic Map

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Metres

NAD 1983 UTM Zone 10N

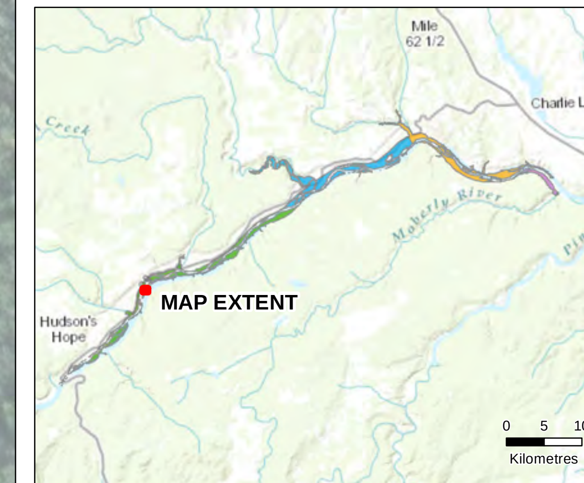
Page Size: 11" x 17"

989619-08	Production Date: Feb 8, 2024	Figure 2-3

Ausenco BC hydro

Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used
- Nest Box - Not Used
- 5 Year Beach Line
- Western Reservoir
- Waterbody

Notes

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- Aerial Image: ESRI World Imagery
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Metres

NAD 1983 UTM Zone 10N

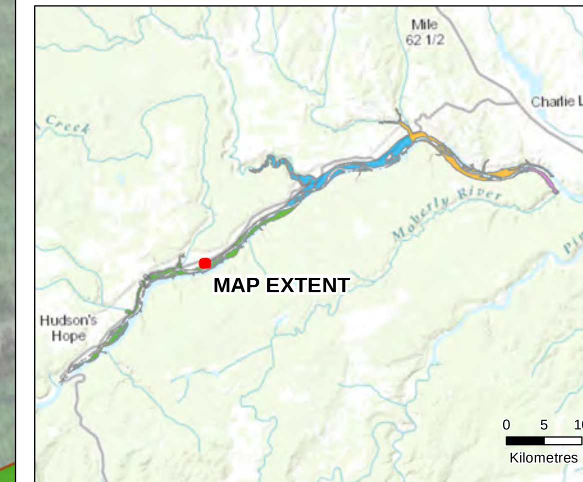
Page Size: 11" x 17"

989619-08	Production Date: Feb 8, 2024	Figure 2-4

Ausenco BChydro

Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used
- 5 Year Beach Line
- Western Reservoir
- Waterbody

Notes

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- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-08	Production Date: Feb 8, 2024	Figure 2-5

Ausenco BChydro

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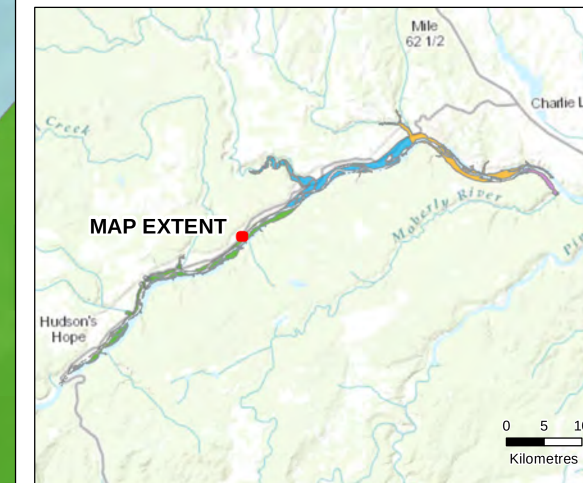
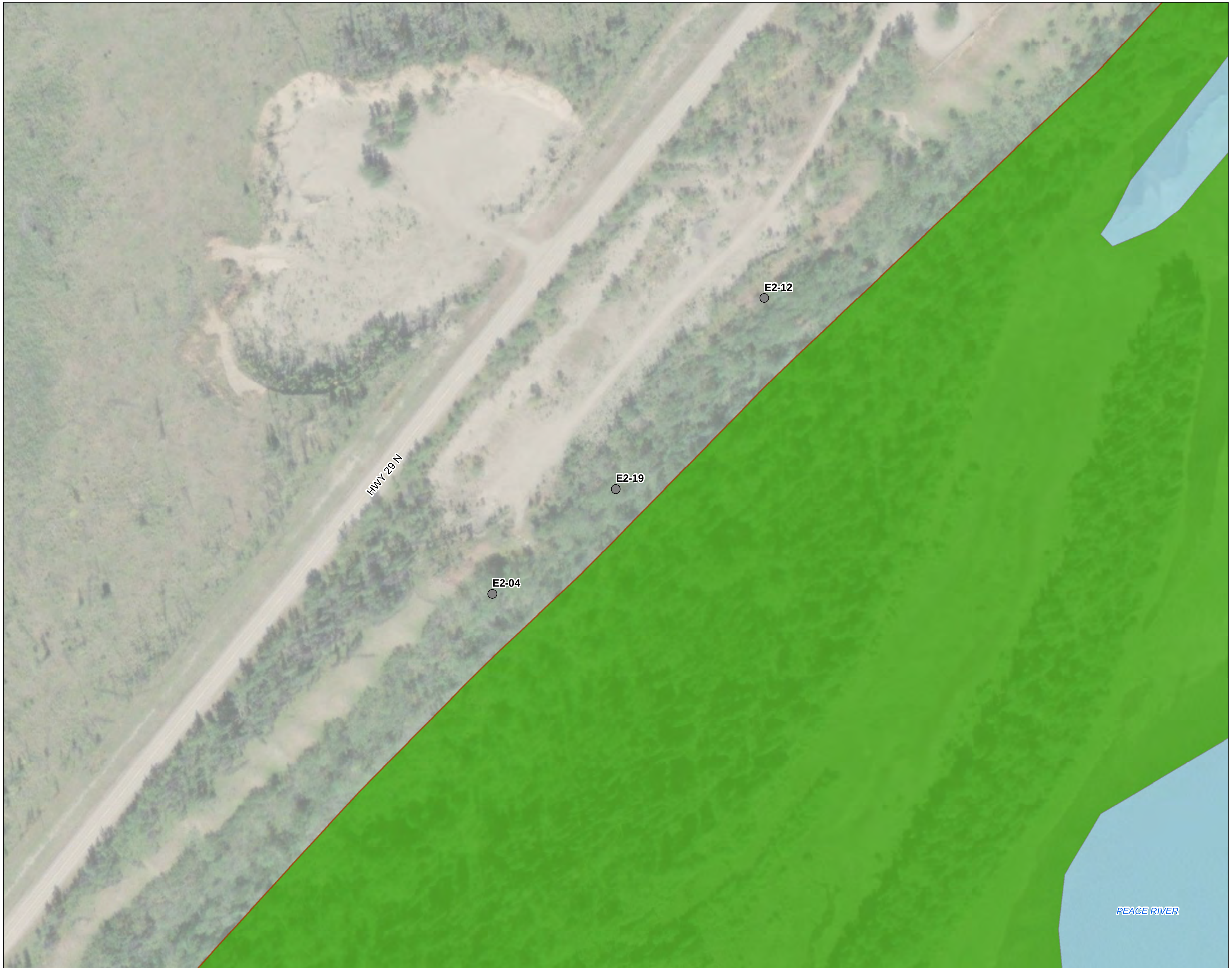
Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes





Legend

- Nest Box - Not Used
- 5 Year Beach Line
- Western Reservoir
- Waterbody

Notes

1. Locations should be considered approximate.
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Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

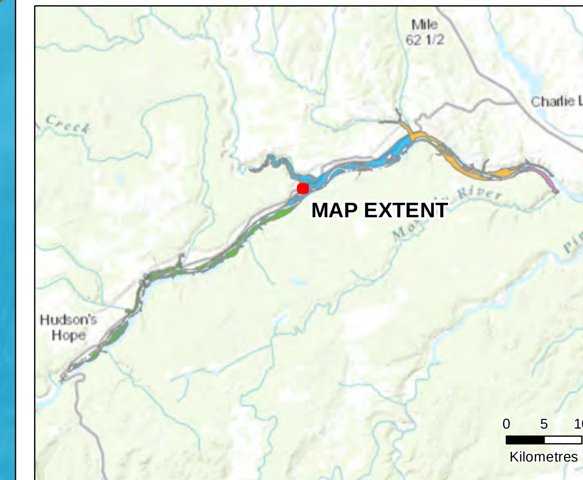
Page Size: 11" x 17"

989619-08	Production Date: Feb 8, 2024	Figure 2-6

Ausenco BC hydro

Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used
- Nest Box - Not Used
- 5 Year Beach Line
- Middle Reservoir
- Waterbody

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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Metres

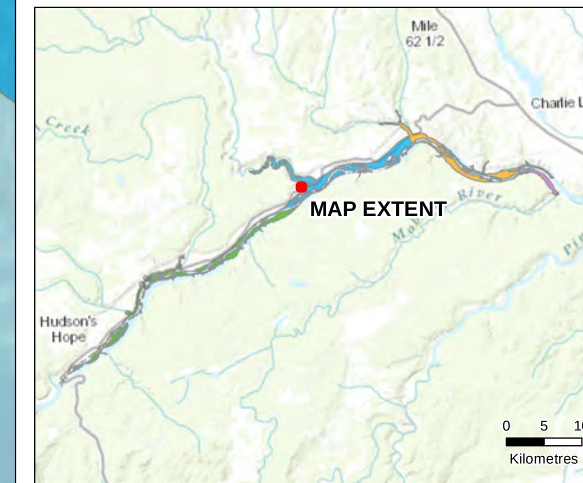
NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-08	Production Date: Feb 8, 2024	Figure 2-7

Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used
- Nest Box - Not Used
- 5 Year Beach Line
- Middle Reservoir
- Waterbody

Notes

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Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

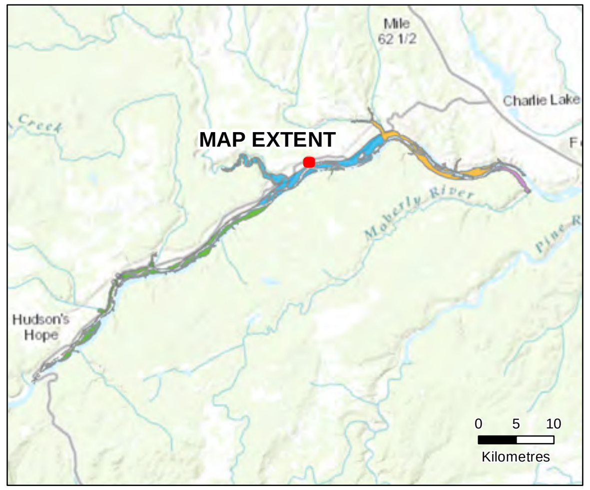
Page Size: 11" x 17"

989619-08	Production Date: Feb 8, 2024	Figure 2-8

Ausenco BChydro

Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

Nest Box - Not Used

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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Metres

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989619-08	Production Date: Feb 8, 2024	Figure 2-9

Ausenco BC hydro

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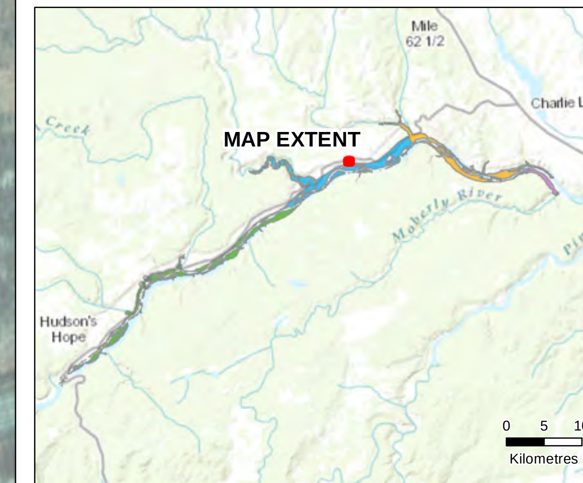
Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used
- Nest Box - Not Used

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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0 20 40 60 80 100
Metres

NAD 1983 UTM Zone 10N

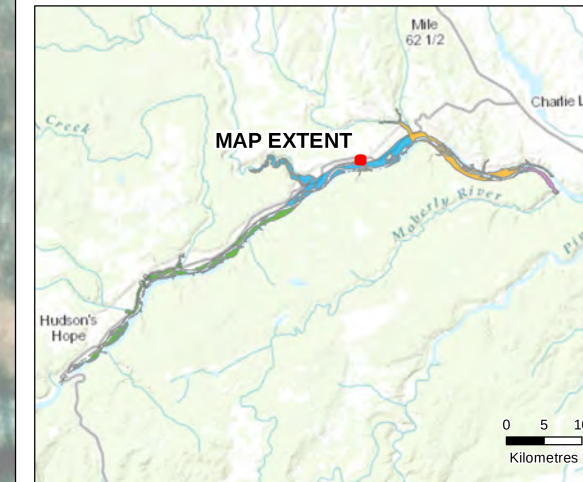
Page Size: 11" x 17"

989619-08	Production Date: Feb 8, 2024	Figure 2-10

Ausenco BChydro

Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used

Notes

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Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

N

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Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-08	Production Date: Feb 8, 2024	Figure 2-11

Ausenco   BC hydro

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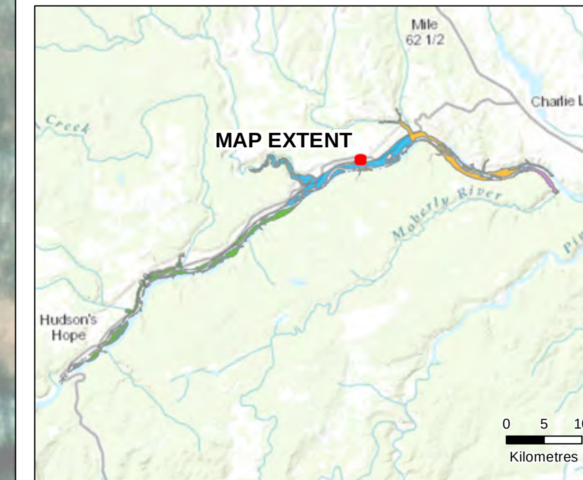

Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes

Legend

Nest Box - Used

Notes

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Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

N

1:2,000

0 20 40 60 80 100

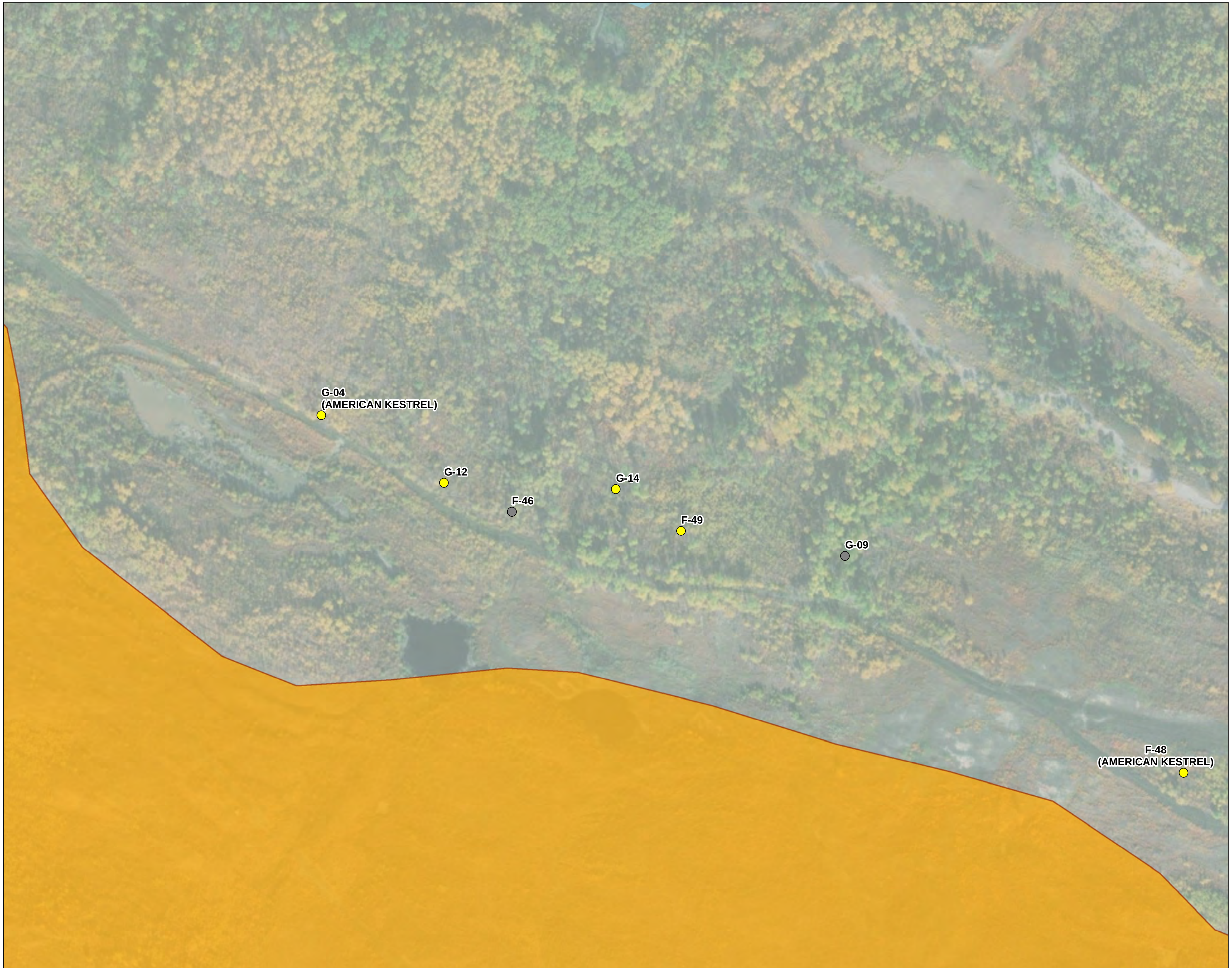
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

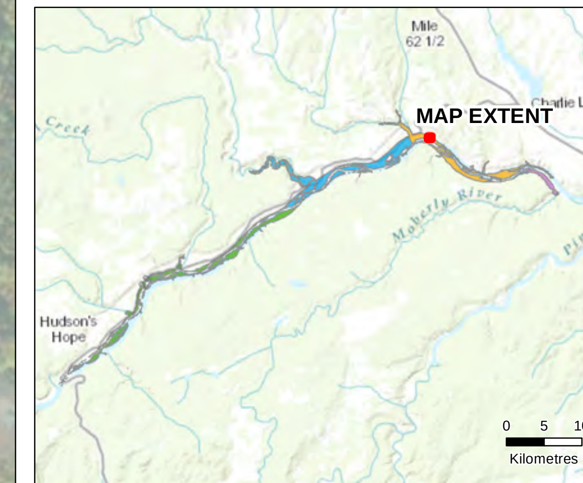
989619-08	Production Date: Feb 8, 2024	Figure 2-12

Ausenco BChydro



Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used
- Nest Box - Not Used
- 5 Year Beach Line
- Eastern Reservoir

Notes

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Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

N

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0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

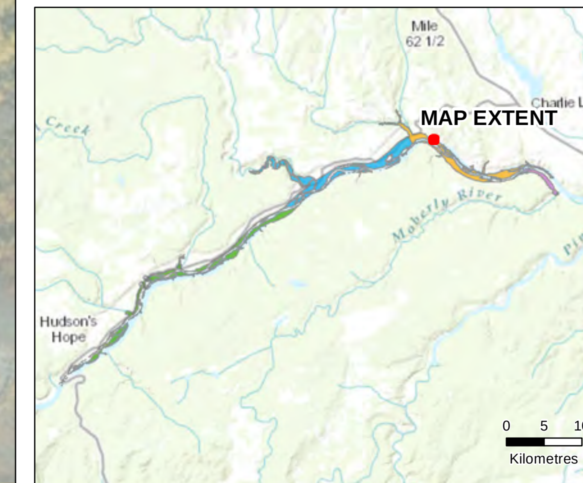
Page Size: 11" x 17"

989619-08	Production Date: Feb 8, 2024	Figure 2-13

Ausenco BChydro

Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used
- 5 Year Beach Line
- Eastern Reservoir

Notes

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N

1:2,000

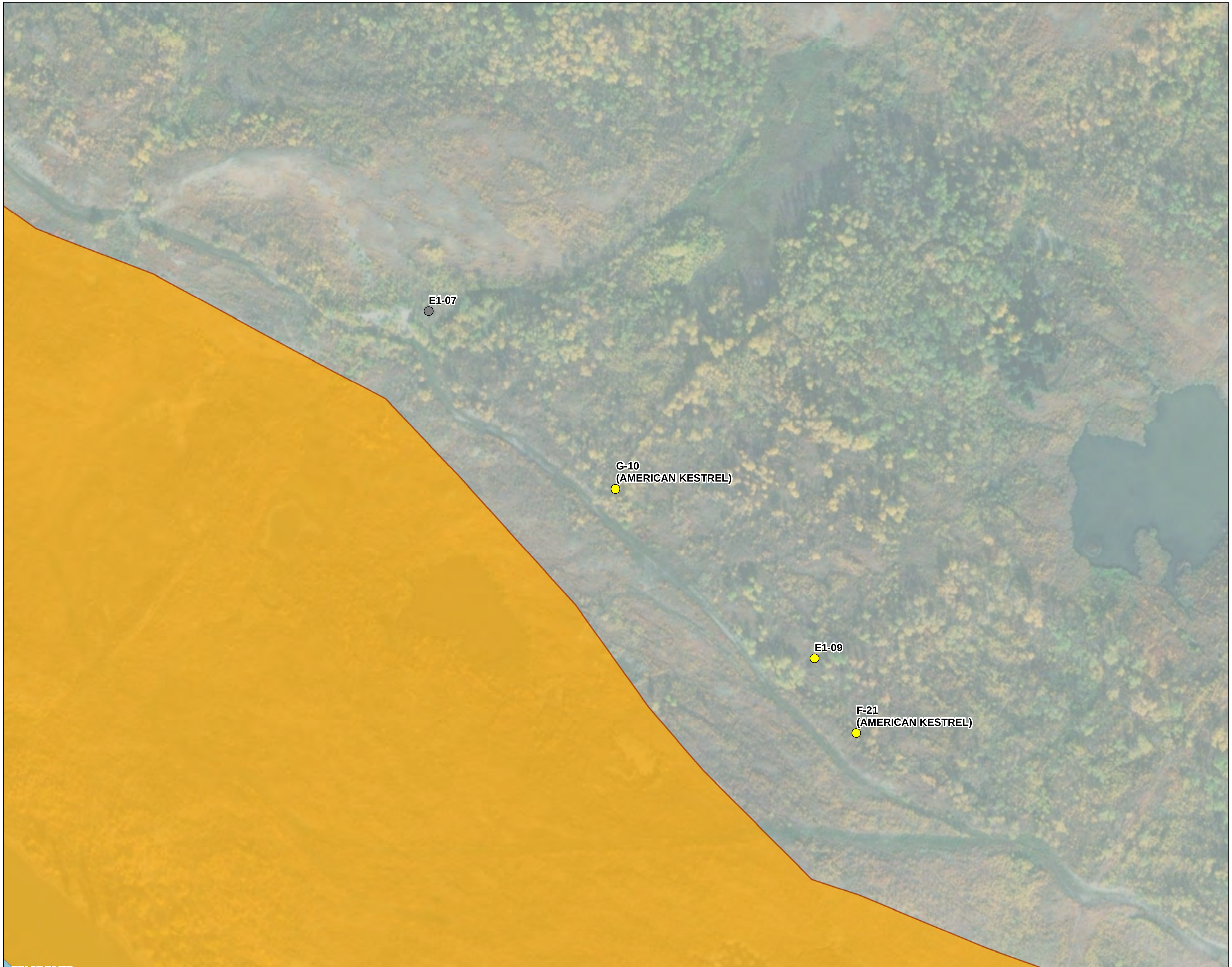
0 20 40 60 80 100
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

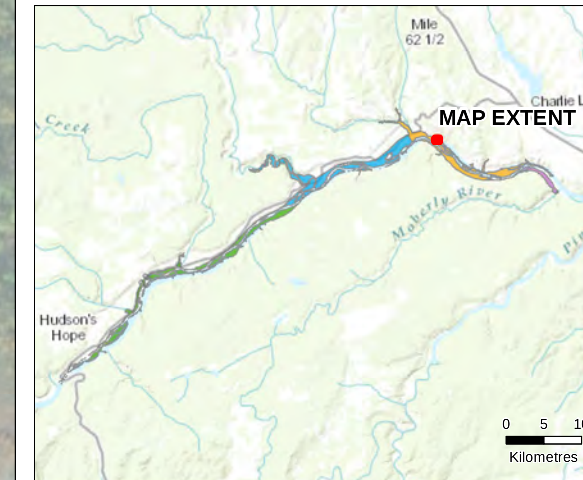
989619-08	Production Date: Feb 8, 2024	Figure 2-14

Ausenco BC hydro



Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used
- Nest Box - Not Used
- 5 Year Beach Line
- Eastern Reservoir
- Waterbody

Notes

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N

1:2,000

0 20 40 60 80 100
Metres

NAD 1983 UTM Zone 10N

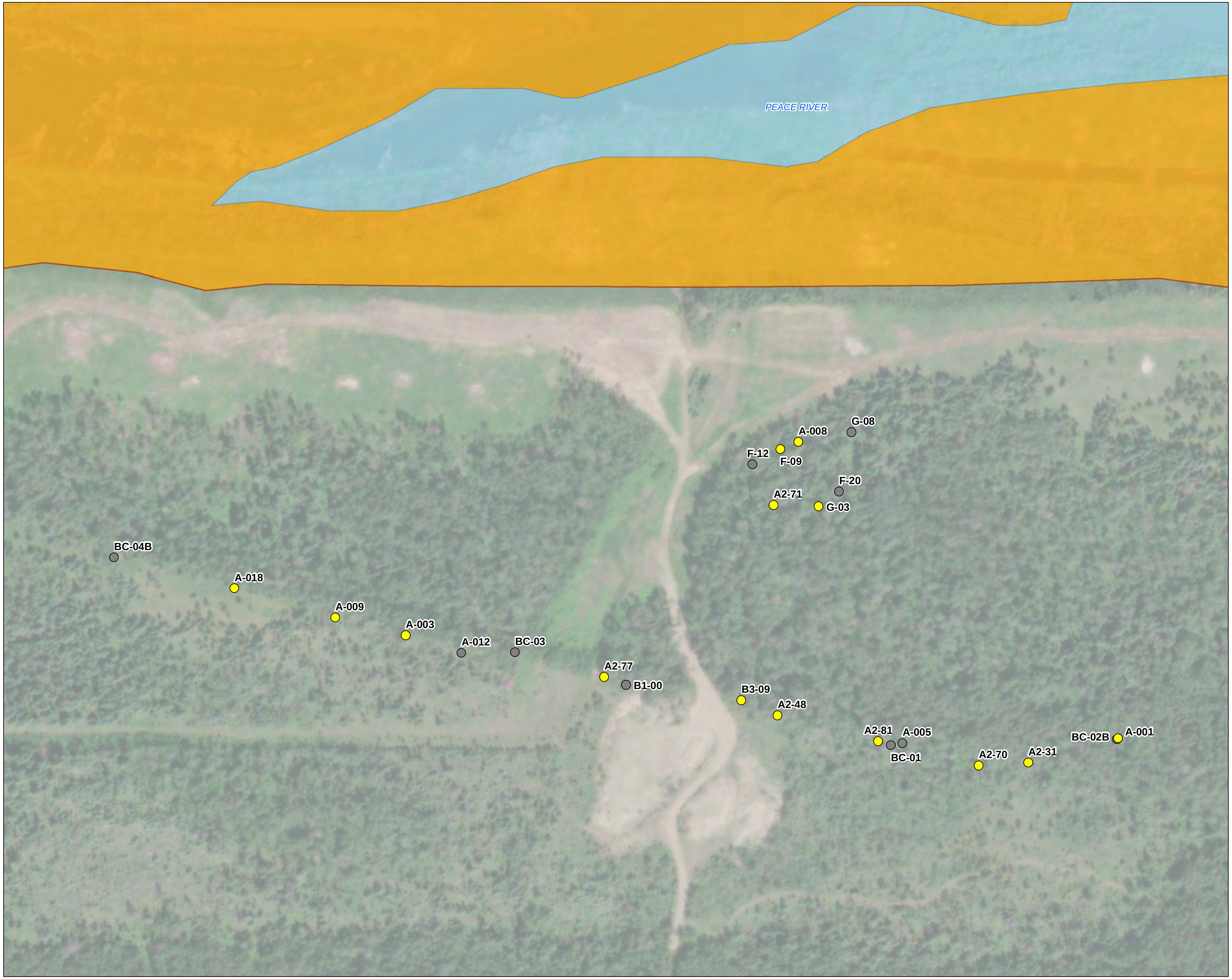
Page Size: 11" x 17"

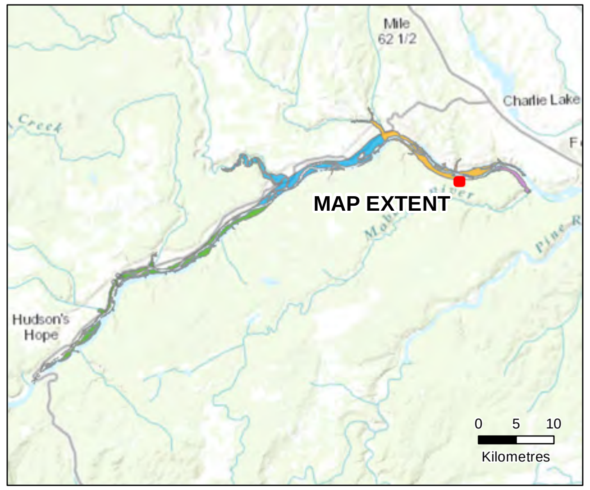
989619-08	Production Date: Feb 8, 2024	Figure 2-15

Ausenco BC hydro

Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes





Legend

- Nest Box - Used
- Nest Box - Not Used
- 5 Year Beach Line
- Eastern Reservoir
- Waterbody

Notes

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0 20 40 60 80 100

Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

989619-08	Production Date: Feb 8, 2024	Figure 2-16

Ausenco BChydro

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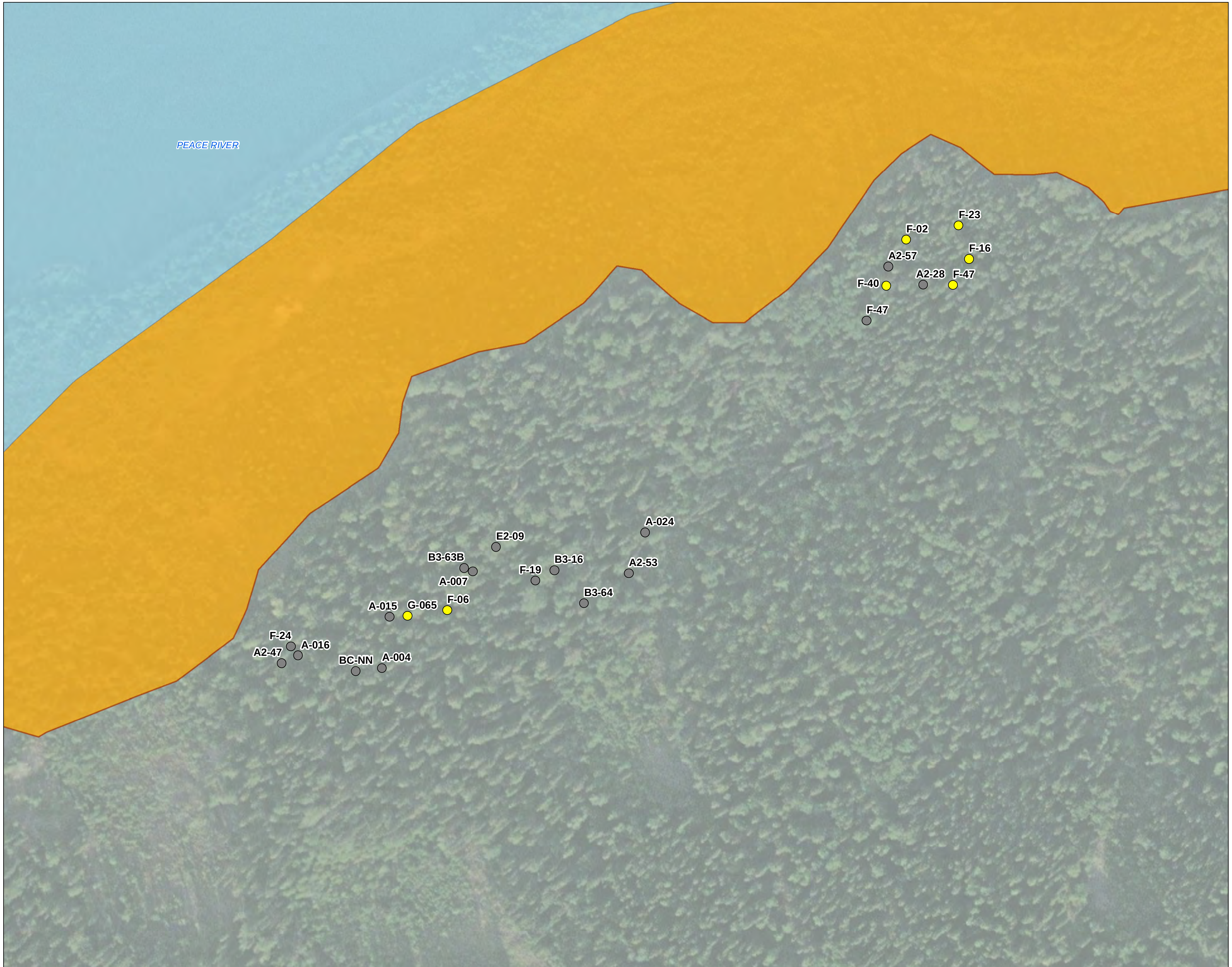
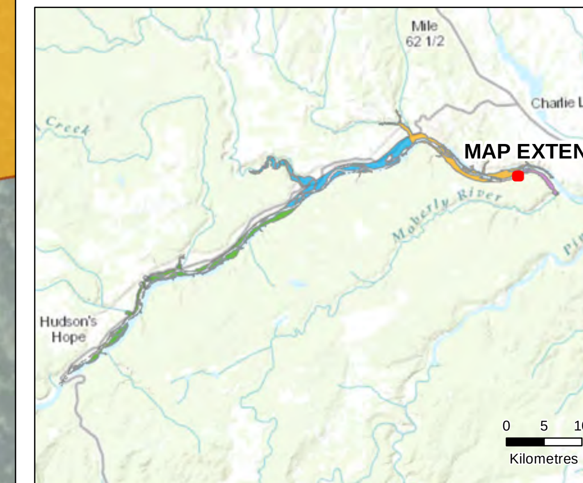


Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used
- Nest Box - Not Used
- 5 Year Beach Line
- Eastern Reservoir
- Waterbody

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N

1:2,000

0 20 40 60 80 100

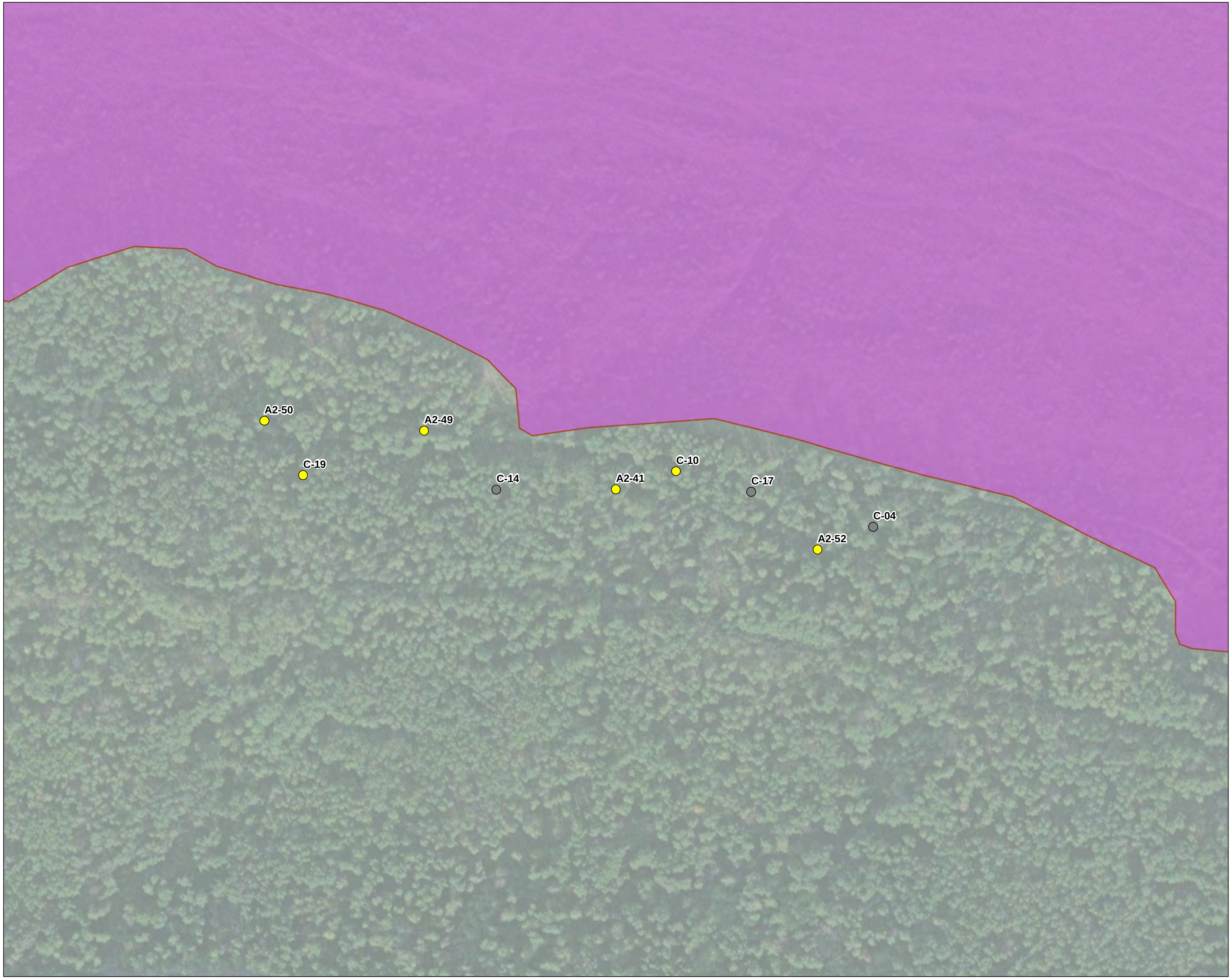
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

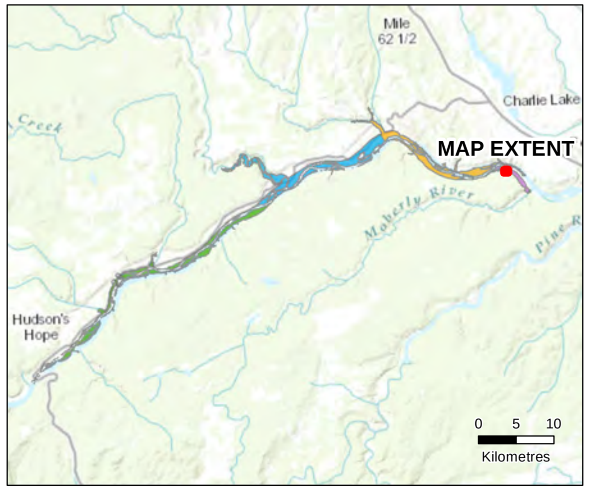
989619-08	Production Date: Feb 8, 2024	Figure 2-17

Ausenco BChydro



Site C Clean Energy Project
Peace River, BC

Location of Nest Boxes



Legend

- Nest Box - Used
- Nest Box - Not Used
- 5 Year Beach Line
- Lower Reservoir

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

N

1:2,000

0 20 40 60 80 100
Metres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

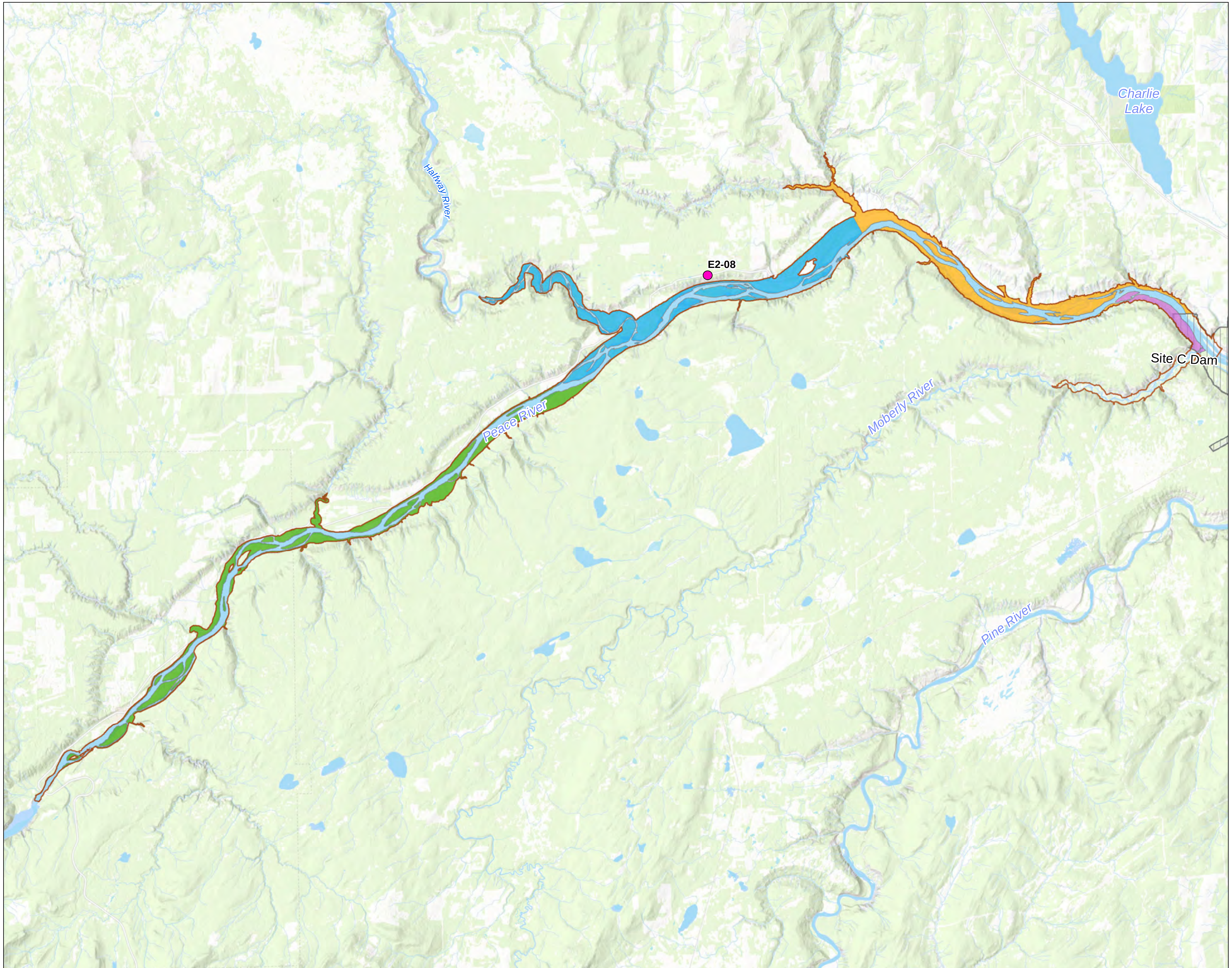
989619-08	Production Date: Feb 8, 2024	Figure 2-18

Ausenco BC hydro

Path: S:\Geomatics\Projects\989619\08_cavity_nest\mxd\2023\Fig2_107576_03_CavityNest_Loc_240208.mxd

Site C Clean Energy Project
Peace River, BC

Location of Box Used by Saw-whet Owl



Legend

- Saw-whet owl Nest Box
- Dam Site
- 5 Year Beach Line
- Eastern Reservoir
- Lower Reservoir
- Middle Reservoir
- Western Reservoir

Notes

1. Locations should be considered approximate.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basemap: ESRI World Topographic Map

N

1:210,000

0 2 4 6 8 10

Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

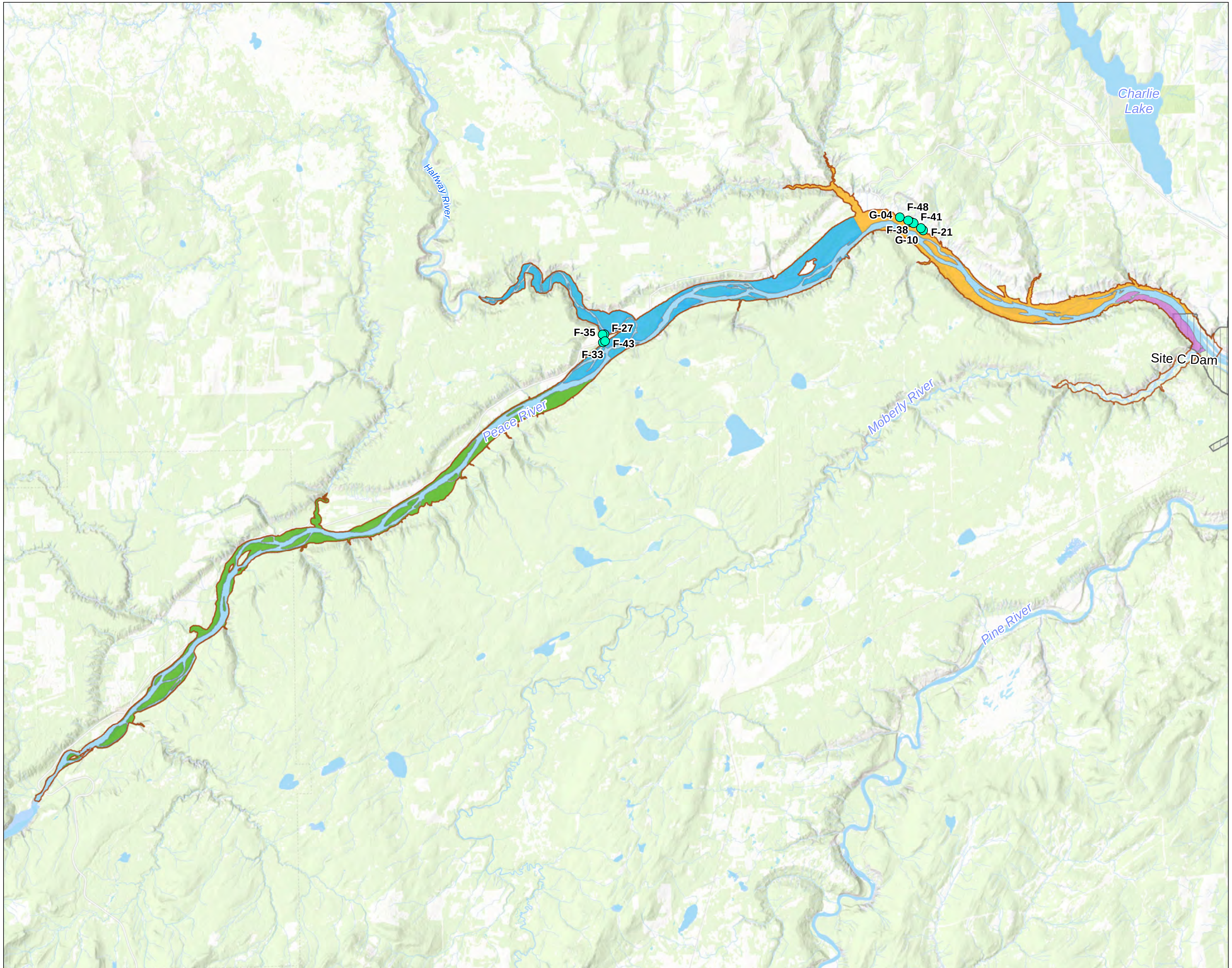
107578-03	Production Date: Feb 9, 2024	Figure 3

Ausenco BC hydro

Path: S:\Geomatics\Projects\989619\08_cavity_nest\mxd\2023\Fig3__107578_03_CavityNest_SawWhetOwl_240209.mxd

Site C Clean Energy Project
Peace River, BC

Location of Boxes Used by American Kestrel



Legend

- American Kestrel Nest Box
- Dam Site
- 5 Year Beach Line
- Eastern Reservoir
- Lower Reservoir
- Middle Reservoir
- Western Reservoir

Notes

1. Locations should be considered approximate.
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Sources

- Basemap: ESRI World Topographic Map

N

1:210,000

0 2 4 6 8 10

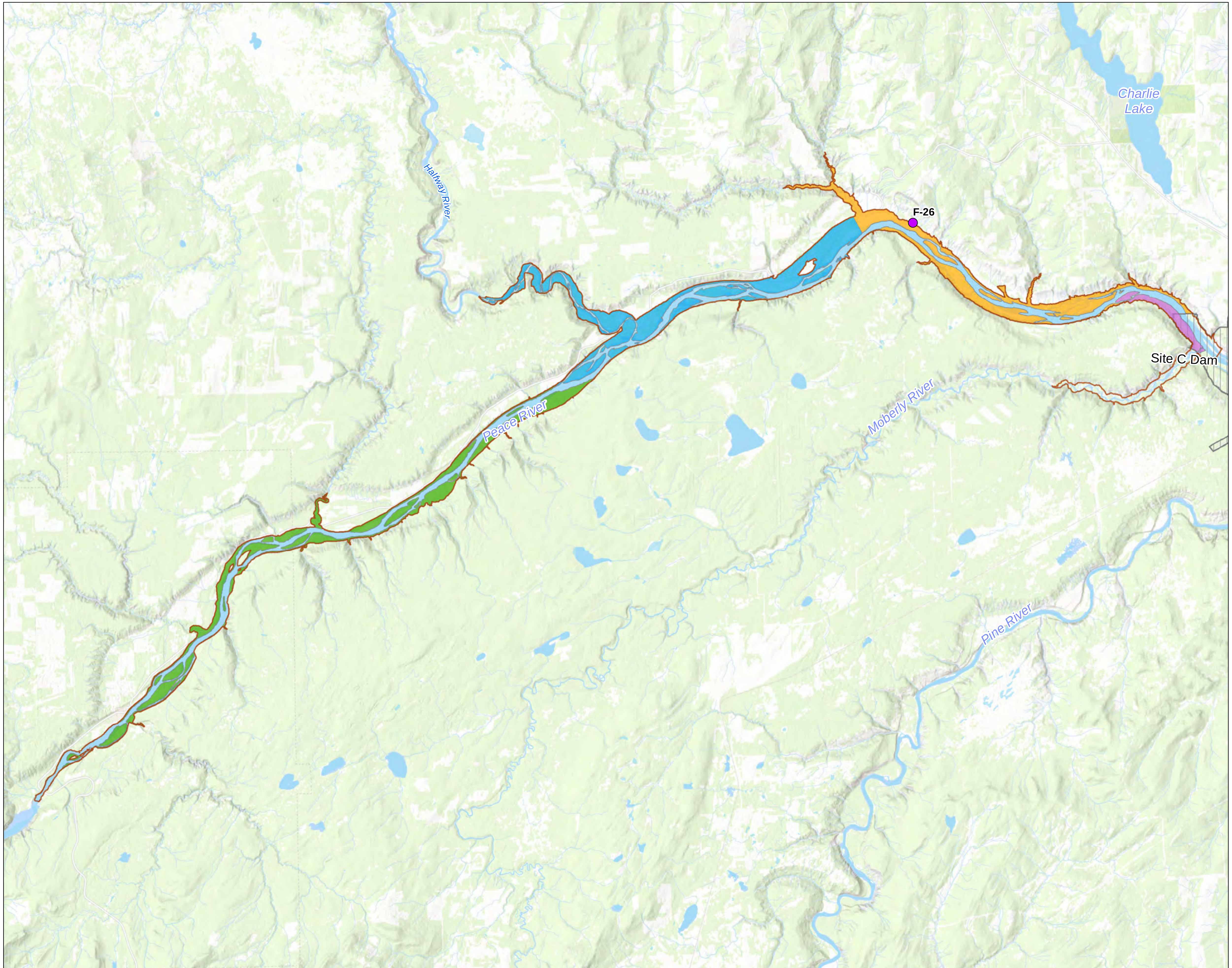
Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

107578-03	Production Date: Feb 9, 2024	Figure 4

Ausenco BChydro



Site C Clean Energy Project
Peace River, BC

Location of Box Used by Goldeneye

Legend

- Goldeneye Nest Box
- Dam Site
- 5 Year Beach Line
- Eastern Reservoir
- Lower Reservoir
- Middle Reservoir
- Western Reservoir

Notes

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Sources

- Basemap: ESRI World Topographic Map

N

1:210,000

0 2 4 6 8 10

Kilometres

NAD 1983 UTM Zone 10N

Page Size: 11" x 17"

107578-03	Production Date: Feb 9, 2024	Figure 5

Ausenco BC hydro

During the monitoring period, four boxes were not located (A2-42, F-05, F-14, and OWL-03). It is suspected that these boxes were removed during the construction work, with the box F-05 being potentially destroyed by a windstorm and the remnants of the box buried under debris. The boxes that were not used by nesting birds or other animals underwent maintenance work and had new nesting material added. It was observed that most boxes that exhibited signs of being used were packed with nesting material, requiring cleaning in preparation for the upcoming 2024 nesting period (**Photo 9 - Photo 10**). Given the uncertainty of whether the boxes were currently being used, performing maintenance work during the monitoring period was deemed impractical or unadvisable.

Photo 9 Nest box full

Photo 10 Nest box full

4.0 Discussion

Out of the 144 nest boxes scheduled for monitoring in 2023, nine were not found, one was deactivated, and five were damaged by wildlife or weather (see **Appendix C**). This left a total of 128 boxes available for nesting. Among these, 70 boxes (55%) showed some signs of use, although it was unclear in some cases whether the nesting material observed in the box was from birds or rodents. Seventeen of the 128 boxes (13%) were occupied by birds, including nestlings, adults, and eggs. American Kestrels were found to be using the boxes, as well as two flying squirrels and one red squirrel at the time of monitoring.

In 2023, the observed occupancy rate of 55% represents an increase from the 35% recorded in 2021 (Hemmera Envirochem Inc. 2022) and the 42% observed in 2022 (Ausenco Sustainability Inc. 2023). This rate aligns with findings from other research on artificial nests across various species (Milligan and Dickinson 2016), as well as specific studies on waterfowl in the Pace Region near Hudson's Hope, which demonstrated a 51% usage rate of installed nest boxes (Blackbird Environmental Ltd. 2021).

American Kestrels' use of nest boxes in 2023 surpassed that observed in the 2021 surveys of boxes installed in 2019 and 2020. Sixteen boxes were used by American Kestrels in 2023, a significant increase from the two boxes noted in 2021. Two boxes from the 2021 survey were used again in 2023, with one box (D-03) containing a terminated nest and another (E1-09) housing five nestlings. American Kestrels occupied fourteen additional boxes in 2023, as detailed in Appendix C. Furthermore, a box used by a Goldeneye in 2023 (F-26) was previously used by waterfowl in 2021. Other boxes reported in 2021 (F-49 and G-04) were used again, though F-49 contained only nesting material, making species identification unfeasible, and G-04, intended for Common Merganser, was occupied by an American Kestrel.

Several boxes were filled with old nesting material, with some overflowing, making the interior easily accessible to predators (see Photos 7-8). Since the monitoring work is scheduled during active nesting, no maintenance was conducted on these boxes, as birds could potentially be using them. It is recommended to carry out maintenance on the boxes before the next nesting period, ideally before the end of March of 2024 (see Appendix B for species-specific breeding periods).

5.0 Closure

We sincerely appreciate the opportunity to have assisted you with this project and if there are any questions, please do not hesitate to contact the undersigned by phone at 604.669.0424.

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6.0 References

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Appendix A
Monitoring and Maintenance Schedule

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
A-002	A	2017		O		X		X	
A-010	A	2017		O		X		X	
A-011	A	2017		O		X		X	
A-014	A	2017		O		X		X	
A-017	A	2017		O		X		X	
A-020	A	2017		O		X		X	
A-021	A	2017		O		X		X	
A-025	A	2017		O		X		X	
A2-35	A2	2017		O		X		X	
A2-36	A2	2017		O		X		X	
A2-37	A2	2017		O		X		X	
A2-44*	A2	2017		*		X		X	
A2-45	A2	2017		O		X		X	
A2-51	A2	2017		O		X		X	
A2-55	A2	2017		O		X		X	
A2-58*	A2	2017		*		X		X	
A2-59	A2	2017		O		X		X	
A2-62*	A2	2017		*		X		X	
A2-66*	A2	2017		*		X		X	
A2-72*	A2	2017		O		X		X	
A2-74	A2	2017		O		X		X	
A2-75	A2	2017		O		X		X	
A2-76	A2	2017		O		X		X	
A2-79	A2	2017		O		X		X	
B1-01	B1	2017		O		X		X	
B1-02	B1	2017		O		X		X	
B1-03	B1	2017		O		X		X	
B1-06	B1	2017		O		X		X	
B2-03	B2	2017		O		X		X	
B2-06	B2	2017		O		X		X	
B3-02	B3	2017		O		X		X	
B3-03	B3	2017		O		X		X	
B3-05	B3	2017		O		X		X	
B3-06	B3	2017		O		X		X	
B3-07	B3	2017		O		X		X	
B3-10*	B3	2017		*		X		X	
B3-11	B3	2017		O		X		X	
B3-12	B3	2017		O		X		X	
B3-13	B3	2017		O		X		X	

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
B3-14	B3	2017		O		X		X	
B3-16*	B3	2017		*		X		X	
B3-17	B3	2017		O		X		X	
B3-20	B3	2017		O		X		X	
BC-01	BC	2017		O		X		X	
BC-02	BC	2017		O		X		X	
BC-03	BC	2017		O		X		X	
BC-05	BC	2017		O		X		X	
C-01	C	2017		O		X		X	
C-02*	C	2017		*		X		X	
C-03	C	2017		O		X		X	
C-08	C	2017		O		X		X	
C-12	C	2017		O		X		X	
C-13	C	2017		O		X		X	
C-15*	C	2017		*		X		X	
C-18	C	2017		O		X		X	
C-22	C	2017		O		X		X	
E1-02	E1	2017		O		X		X	
E1-05*	E1	2017		*		X		X	
E2-01	E2	2017		O		X		X	
E2-02	E2	2017		O		X		X	
E2-03*	E2	2017		*		X		X	
E2-06	E2	2017		O		X		X	
E2-10	E2	2017		O		X		X	
E2-13	E2	2017		O		X		X	
E2-17	E2	2017		O		X		X	
E2-20*	E2	2017		*		X		X	
E2-21	E2	2017		O		X		X	
E2-27*	E2	2017		*		X		X	
E2-28	E2	2017		O		X		X	
E3-01	E3	2017		O		X		X	
E3-02	E3	2017		O		X		X	
E3-03	E3	2017		O		X		X	
E3-04	E3	2017		O		X		X	
E3-05	E3	2017		O		X		X	
E3-07*	E3	2017		*		X		X	
E3-09*	E3	2017		*		X		X	
E3-11*	E3	2017		*		X		X	
E3-12*	E3	2017		*		X		X	

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
E3-13	E3	2017		O		X		X	
E3-14*	E3	2017		*		X		X	
E3-15*	E3	2017		*		X		X	
E3-16	E3	2017		O		X		X	
F-03*	F	2017		*		X		X	
F-07*	F	2017		*		X		X	
F-08*	F	2017		*		X		X	
F-11	F	2017		O		X		X	
F-17	F	2017		O		X		X	
F-18	F	2017		O		X		X	
F-29	F	2017		O		X		X	
F-31	F	2017		O		X		X	
F-32*	F	2017		*		X		X	
F-42*	F	2017		*		X		X	
G-07*	G	2017		*		X		X	
G-08*	G	2017		*		X		X	
G-13	G	2017		O		X		X	
G-15	G	2017		O		X		X	
A-004	A	2019	O		X		X		X
A-006	A	2019	O		X		X		X
A-007	A	2019	O		X		X		X
A-013	A	2019	O		X		X		X
A-015	A	2019	O		X		X		X
A-016	A	2019	O		X		X		X
A-022	A	2019	O		X		X		X
A-024	A	2019	O		X		X		X
A-026	A	2019	O		X		X		X
A2-27	A2	2019	O		X		X		X
A2-28	A2	2019	O		X		X		X
A2-29	A2	2019	O		X		X		X
A2-30	A2	2019	O		X		X		X
A2-32	A2	2019	O		X		X		X
A2-33	A2	2019	-		X		X		X
A2-34	A2	2019	-		X		X		X
A2-38	A2	2019	O		X		X		X
A2-39	A2	2019	O		X		X		X
A2-42	A2	2019	O		X		X		X
A2-46	A2	2019	O		X		X		X
A2-47	A2	2019	O		X		X		X

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
A2-53	A2	2019	O		X		X		X
A2-56	A2	2019	O		X		X		X
A2-57	A2	2019	O		X		X		X
A2-63	A2	2019	-		X		X		X
A2-64	A2	2019	O		X		X		X
A2-67	A2	2019	O		X		X		X
A2-68	A2	2019	O		X		X		X
A2-69	A2	2019	O		X		X		X
A2-80	A2	2019	O		X		X		X
B1-04	B1	2019	O		X		X		X
B1-05	B1	2019	O		X		X		X
B1-06b	B1	2019	O		X		X		X
B2-01	B2	2019	O		X		X		X
B2-02	B2	2019	O		X		X		X
B2-04	B2	2019	O		X		X		X
B2-05	B2	2019	O		X		X		X
B3-01	B3	2019	O		X		X		X
B3-04	B3	2019	O		X		X		X
B3-08	B3	2019	O		X		X		X
B3-15	B3	2019	O		X		X		X
B3-18	B3	2019	O		X		X		X
BC-04	BC	2019	O		X		X		X
C-21	C	2019	O		X		X		X
E2-11	E2	2019	O		X		X		X
E2-18	E2	2019	O		X		X		X
E2-26	E2	2019	O		X		X		X
F-02	F	2019	O		X		X		X
F-04	F	2019	O		X		X		X
F-05	F	2019	O		X		X		X
F-06	F	2019	O		X		X		X
F-10	F	2019	O		X		X		X
F-14	F	2019	O		X		X		X
F-15	F	2019	O		X		X		X
F-16	F	2019	O		X		X		X
F-19	F	2019	O		X		X		X
F-22	F	2019	O		X		X		X
F-23	F	2019	O		X		X		X
F-24	F	2019	O		X		X		X
F-25	F	2019	O		X		X		X

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
F-28	F	2019	O		X		X		X
F-30	F	2019	O		X		X		X
F-37	F	2019	O		X		X		X
F-39	F	2019	O		X		X		X
F-40	F	2019	O		X		X		X
F-47	F	2019	O		X		X		X
G-05	G	2019	O		X		X		X
OWL-2	H	2020	O		X		X		X
OWL-3	H	2020	O		X		X		X
A-001	A	2020	O		X		X		X
A-003	A	2020	O		X		X		X
A-005	A	2020	O		X		X		X
A-009	A	2020	O		X		X		X
A-012	A	2020	O		X		X		X
A-018	A	2020	O		X		X		X
A2-31	A2	2020	O		X		X		X
A2-41	A2	2020	O		X		X		X
A2-48	A2	2020	O		X		X		X
A2-49	A2	2020	O		X		X		X
A2-50	A2	2020	O		X		X		X
A2-52	A2	2020	O		X		X		X
A2-61	A2	2020	O		X		X		X
A2-70	A2	2020	O		X		X		X
A2-81	A2	2020	O		X		X		X
B1-00	B1	2020	O		X		X		X
B3-09	B3	2020	O		X		X		X
B3-19	B3	2020	O		X		X		X
BC-01S	BC	2020	O		X		X		X
BC-02b	BC	2020	O		X		X		X
BC-03b	BC	2020	O		X		X		X
BC-04b	BC	2020	O		X		X		X
BC-NN	BC	2020	O		X		X		X
C-04	C	2020	O		X		X		X
C-05	C	2020	O		X		X		X
C-06	C	2020	O		X		X		X
C-09	C	2020	O		X		X		X
C-10	C	2020	O		X		X		X
C-11	C	2020	O		X		X		X
C-14	C	2020	O		X		X		X

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
C-16	C	2020	O		X		X		X
C-17	C	2020	O		X		X		X
C-19	C	2020	O		X		X		X
C-20	C	2020	O		X		X		X
C-23	C	2020	O		X		X		X
C-X1	C	2020	O		X		X		X
C-X2	C	2020	O		X		X		X
C-X3	C	2020	O		X		X		X
D-01	D	2020	O		X		X		X
D-02	D	2020	O		X		X		X
D-03	D	2020	O		X		X		X
E1-01	E1	2020	O		X		X		X
E1-03	E1	2020	O		X		X		X
E1-04	E1	2020	O		X		X		X
E1-07	E1	2020	O		X		X		X
E1-09	E1	2020	O		X		X		X
E2-04	E2	2020	O		X		X		X
E2-05	E2	2020	O		X		X		X
E2-07	E2	2020	O		X		X		X
E2-08	E2	2020	O		X		X		X
E2-12	E2	2020	O		X		X		X
E2-14	E2	2020	O		X		X		X
E2-15	E2	2020	O		X		X		X
E2-16	E2	2020	O		X		X		X
E2-19	E2	2020	O		X		X		X
E2-22	E2	2020	O		X		X		X
E2-23	E2	2020	O		X		X		X
E2-25	E2	2020	O		X		X		X
E2-27b	E2	2020	O		X		X		X
E3-01b	E3	2020	O		X		X		X
E3-08	E3	2020	O		X		X		X
F-01	F	2020	O		X		X		X
F-13	F	2020	O		X		X		X
F-21	F	2020	O		X		X		X
F-26	F	2020	O		X		X		X
F-27	F	2020	O		X		X		X
F-33	F	2020	O		X		X		X
F-34	F	2020	-		X		X		X
F-35	F	2020	O		X		X		X

Nest Box ID	Nest Box Type	Year Installed	Monitoring and Maintenance Schedule until 2027 (10 years after initial installation)						
			2021	2022	2023	2024	2025	2026	2027
F-36	F	2020	O		X		X		X
F-38	F	2020	O		X		X		X
F-41	F	2020	O		X		X		X
F-43	F	2020	O		X		X		X
F-45	F	2020	O		X		X		X
F-46	F	2020	O		X		X		X
F-48	F	2020	O		X		X		X
F-49	F	2020	O		X		X		X
G-01	G	2020	O		X		X		X
G-02	G	2020	O		X		X		X
G-04	G	2020	O		X		X		X
G-06	G	2020	O		X		X		X
G-09	G	2020	O		X		X		X
G-10	G	2020	O		X		X		X
G-12	G	2020	O		X		X		X
G-14	G	2020	O		X		X		X

Notes:

X indicates the scheduled year for monitoring and maintenance; no boxes were installed in 2019.

O indicates boxes that were already monitored

* indicates boxes that were not found

- indicates boxes which could not be found in 2021, which were either missed during monitoring or destroyed during inclement weather. These boxes were searched again in 2023 but not found.

Appendix B
Breeding Periods for Survey Timing

Species Group	Focal Species	Breeding Window Date Range[1, 2]	Late Incubation to Early Nestling Stages Date Range[2, 3]
Passerines	Black-Capped Chickadee	Early March to early August	Mid-March to mid-July
	Boreal Chickadee	Mid-May to mid-July	Mid-May to mid-July
	Brown Creeper	Early April to late July	Early May to mid-June
	Red-Breasted Nuthatch	Early April to late July	Mid-May to mid-June
	White-Breasted Nuthatch	Mid-April to early July	
	Tree Swallow	Mid-April to mid-September	Mid-May to mid-August
	Violet-Green Swallow	Early April to late August	Early May to mid-July
	House Wren	Mid-April to late August	Early May to mid-August
	Mountain Bluebird	Late March to early August	Mid-May to late July
Waterfowl	Barrow's Goldeneye	Mid-March to late August	Early May to mid-July
	Bufflehead	Mid-April to late August	Early June to mid-July
	Common Goldeneye	Early April to late August	Early May to mid-July
	Common Merganser	Early March to early September	Mid-April to late June
	Hooded Merganser	Late March to early October	Early May to early July
Raptors and Owls	Barred Owl	Mid-March to mid-August	Mid-April to late May
	Boreal Owl	Early April to mid-July	
	Northern Saw-Whet Owl	Early March to mid-August	Early April to mid-June
	Northern Pygmy Owl	Mid-April to late August	Mid-May to mid-June
	Northern Hawk-Owl	Mid-April to early August	
	American Kestrel	Early April to late August	Early April to mid-July

Notes:
[1] the range of dates from egg-laying to fledging in BC for each focal species.
[2] information is based on (Campbell et al. 1990; Campbell et al. 1997)
[3] the range of dates when nests in BC are likely to be in the late incubation or early nestling stages.

Appendix C

2023 Monitoring and Maintenance Results

2023 Monitoring Date	Nest Box ID	Nest Box Type	Survey Methods	Current Use	Bird Species Using Box	Box Status	Maintenance Completed	Comments
June 15, 2023	A-001	A	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Twig nest inside. No signs of activity. The nest was left intact
June 15, 2023	A-003	A	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Stick nest inside with some feathers. Other A and A2 boxes have similar nests
June 15, 2023	A-004	A	NA	Not Found	NA	Operational	Not Found	Not found
June 15, 2023	A-005	A	NA	No	None	Operational	Nest material added	Nest box was found on the ground. It was potentially hit by a tree. The box was in good conditions and was reinstalled on a spruce at the same location
June 14, 2023	A-006	A	Pole camera examination	No	None	Operational	Nest material added	Nest wasp inside
June 15, 2023	A-007	A	Visual inspection	No	None	Operational	Nest material added	-
June 15, 2023	A-008	A	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Stick nest inside
June 15, 2023	A-009	A	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Stick nest inside
June 15, 2023	A-012	A	Pole camera examination	No	None	Operational	Nest material added	-
June 14, 2023	A-013	A	Pole camera examination	No	None	Operational	Nest material added	-
June 15, 2023	A-015	A	Pole camera examination	No	None	Operational	Nest material added	-
June 15, 2023	A-016	A	Pole camera examination	Unknown	NA	Operational	No. Not inspected due to wasp attack	Wasps inside. Not inspected
June 15, 2023	A-018	A	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Stick nest inside with some feathers. Other A and A2 boxes have similar nests
June 14, 2023	A-022	A	Pole camera examination	Not Found	NA	Operational	Not Found	-
June 15, 2023	A-024	A	Visual inspection	No	None	Operational	Nest material added	-
June 14, 2023	A-026	A	Pole camera examination	No	None	Operational	Nest material added	Wasp nest inside the box. Wasp nest removed. New nesting material added
June 15, 2023	A2-27	A2	NA	Not Found	NA	Operational	Not Found	-
June 15, 2023	A2-28	A2	Visual inspection	No	None	Operational	Nest material added	-
June 14, 2023	A2-30	A2	Pole camera examination	No	None	Operational	Nest material added	-
June 15, 2023	A2-31	A2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Minor chewing around the entrance. Nest inside (twigs, feathers, leaves, grass). Potentially fletched already
June 15, 2023	A2-33	A2	NA	Not Found	NA	Operational	Not Found	-
June 14, 2023	A2-38	A2	Pole camera examination	No	None	Operational	Nest material added	Wasp nest inside. Wasp nest removed. New nesting material added
June 14, 2023	A2-39	A2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Old nest inside (wood shavings)
June 16, 2023	A2-41	A2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest was left intact
June 14, 2023	A2-42	A2	NA	Not Found	NA	Operational	Not Found	-
June 15, 2023	A2-47	A2	NA	No	None	Operational	Nest material added	Wasps inside. Not inspected
June 15, 2023	A2-48	A2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Twig nest inside similar to other nests found in A2 boxes surveyed in the area
June 16, 2023	A2-49	A2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest was left intact
June 16, 2023	A2-50	A2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest was left intact
June 16, 2023	A2-52	A2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest was left intact
June 15, 2023	A2-53	A2	Visual inspection	No	None	Operational	Nest material added	Wasp nest inside. Wasp nest removed
June 15, 2023	A2-57	A2	Visual inspection	No	None	Operational	Nest material added	-
June 14, 2023	A2-64	A2	NA	Damaged	NA	Non operational	Temporary repaired	Bottom of the box was gone. Box fixed with a temporary bottom
June 14, 2023	A2-67	A2	Pole camera examination	No	None	Operational	Nest material added	Chew marks on entrance, new nesting material added
June 14, 2023	A2-68	A2	Pole camera examination	No	None	Operational	Nest material added	Nesting material added
June 14, 2023	A2-69	A2	Pole camera examination	No	None	Operational	Nest material added	Chewing marks at the entrance. New nesting material added
June 15, 2023	A2-70	A2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Stick nest inside. Nest was left intact
June 15, 2023	A2-71	A2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	One cup nest inside. Grasses, small sticks and a few feathers
June 15, 2023	A2-77	A2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Stick nest inside

2023 Monitoring Date	Nest Box ID	Nest Box Type	Survey Methods	Current Use	Bird Species Using Box	Box Status	Maintenance Completed	Comments
June 15, 2023	A2-81	A2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Stick nest inside with some feathers similar to A2 boxes west from this one
June 15, 2023	B1-00	B1	Pole camera examination	No	None	Operational	NA	No nesting material needed
June 14, 2023	B1-04	B1	Pole camera examination	No	None	Operational	Nest material added	Wasp nest inside. Wasp nest removed. New nesting material added
June 14, 2023	B1-05	B1	Pole camera examination	No	None	Operational	Nest material added	No nesting material needed. Old nesting material was dry and clean
June 14, 2023	B2-01	B2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest inside (Grass, moss, twigs, leaves). Live Wasp nest I inside the bird's nest. Wasp nest removed and new nesting material added
June 14, 2023	B2-02	B2	Pole camera examination	No	None	Operational	Nest material added	-
June 14, 2023	B2-04	B2	Pole camera examination	No	None	Operational	Nest material added	-
June 14, 2023	B2-05	B2	Pole camera examination	No	None	Operational	Nest material added	-
June 14, 2023	B3-01	B3	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Old nest in box, new nesting material added. Old nest was left intact
June 14, 2023	B3-08	B3	Pole camera examination	No	None	Not found	NA	Some old nesting material inside (grasss). New nesting material added
June 15, 2023	B3-09	B3	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Stick nest inside
June 14, 2023	B3-15	B3	Pole camera examination	No	None	Operational	Nest material added	-
June 15, 2023	B3-16	B3	Visual inspection	No	None	Operational	Nest material added	-
June 14, 2023	B3-18	B3	Pole camera examination	No	None	Operational	Nest material added	-
June 17, 2023	B3-19	B3	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest was left intact
June 15, 2023	B3-63b	B3	Visual inspection	No	None	Operational	Nest material added	-
June 15, 2023	B3-64	B3	Visual inspection	No	None	Operational	Nest material added	-
June 15, 2023	BC-01	BC	Pole camera examination	No	None	Operational	Nest material added	No nesting material needed
June 15, 2023	BC-02b	BC	Pole camera examination	No	None	Operational	Nest material added	No nesting material needed (creeper box)
June 15, 2023	BC-03	BC	Pole camera examination	No	None	Operational	Nest material added	-
June 15, 2023	BC-04b	BC	Pole camera examination	No	None	Operational	Nest material added	Empty box. Creeper box, no nesting material needed
June 15, 2023	BC-NN	BC	Visual inspection	No	None	Operational	Nest material added	Creeper box. No nesting material needed
June 16, 2023	C-04	C	Pole camera examination	Small mammal	Small mammal	Operational	No. The box was in use	Some droppings from a small mammal
June 17, 2023	C-06	C	Pole camera examination	No	None	Operational	Nest material added	-
June 17, 2023	C-09	C	Pole camera examination	No	None	Operational	Nest material added	-
June 16, 2023	C-10	C	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest was left intact
June 17, 2023	C-11	C	Pole camera examination	No	None	Operational	Nest material added	-
June 16, 2023	C-14	C	Pole camera examination	Small mammal	Small mammal	Operational	No. The box was in use	Droppings from a small mammal
June 17, 2023	C-16	C	Pole camera examination	No	None	Operational	Nest material added	-
June 16, 2023	C-17	C	Pole camera examination	No	None	Operational	Nest material added	-
June 16, 2023	C-19	C	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	-
June 17, 2023	C-20	C	Pole camera examination	No	None	Operational	Nest material added	-
June 17, 2023	C-23	C	Pole camera examination	No	None	Operational	Nest material added	-
June 17, 2023	C-X1	C	Pole camera examination	No	None	Operational	Nest material added	-
June 17, 2023	C-X2	C	Pole camera examination	No	None	Operational	Nest material added	-
June 17, 2023	C-X3	C	Pole camera examination	No	None	Operational	Nest material added	-
June 18, 2023	D-01	D	Pole camera examination	No	None	Operational	Nest material added	Wasp nest inside. Wasp nest removed. No need for new nesting material
June 18, 2023	D-02	D	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Potentially AMKE
June 18, 2023	D-03	D	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	Potentially AMKE

2023 Monitoring Date	Nest Box ID	Nest Box Type	Survey Methods	Current Use	Bird Species Using Box	Box Status	Maintenance Completed	Comments
June 17, 2023	E1-01	E1	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest was left intact
June 15, 2023	E1-03	E1	NA	Not Found	NA	Gone	Not Found	-
June 17, 2023	E1-04	E1	Pole camera examination	No	None	Operational	Nest material added	-
June 19, 2023	E1-07	E1	NA	Damaged	NA	Non operational	No. It needs major repairs	Box destroyed. Impossible to repair
June 19, 2023	E1-09	E1	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	5 AMKE nestlings inside
June 17, 2023	E2-04	E2	Pole camera examination	Small mammal	Small mammal	Operational	No. The box was in use	Small mammal droppings inside
June 18, 2023	E2-05	E2	Pole camera examination	No	None	Operational	Nest material added	Attempts of a nest. Some scattered leaves in the vaguely shape of a nest (circle at the bottom of the box)
June 15, 2023	E2-07	E2	NA	Not Found	NA	Gone	Not Found	-
June 18, 2023	E2-08	E2	Pole camera examination	Yes	Saw-whet Owl	Operational	No. The box was in use	Four fledglings inside nest no adult on site
June 15, 2023	E2-09	E2	NA	Damaged	NA	Non operational	No. It needs major repairs	A bear broke the bottom and cracked it in half. Needs mayor repair
June 17, 2023	E2-12	E2	Pole camera examination	Rodent	Squirrel	Operational	No. The box was in use	Small mammal droppings inside. New nesting material added.
June 14, 2023	E2-18	E2	Pole camera examination	No	None	Operational	Nest material added	New nesting material added
June 17, 2023	E2-19	E2	Pole camera examination	Rodent	Squirrel	Operational	No. The box was in use	Droppings from small mammal inside (squirrel). New nesting material added
June 18, 2023	E2-23	E2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	No signs of eggs or nestlings from the endoscope image. Nest was left intact
June 18, 2023	E2-25	E2	Pole camera examination	Rodent	Flying squirrel	Operational	No. The box was in use	Flying squirrel
June 18, 2023	E2-27	E2	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	No signs of eggs or nestlings. The nest was left intact
June 18, 2023	E3-08	E3	NA	Deactivated	NA	Temporary non operational	No. It needs to be activated once construction in the area stops	Box has been deactivated. Entrance of next box is blocked with a piece of wood
June 19, 2023	F-01	F	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	-
June 15, 2023	F-02	F	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest inside. Mainly grasses and moss
June 14, 2023	F-04	F	Pole camera examination	No	None	Operational	Nest material added	-
June 14, 2023	F-04 Cont	F	Pole camera examination	No	None	Operational	Nest material added	The nest box had an active wasp nest on it. The nest was removed and new nesting material was added
June 17, 2023	F-05	F	NA	Not Found	NA	Gone	Not Found	Not on site. Potentially removed due to construction
June 15, 2023	F-06	F	Visual inspection	Yes	Unknown	Operational	No. The box was in use	Got stung and chased by wasps. Old nest inside
June 15, 2023	F-09	F	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Grass nest inside. No new material added. The nest was left intact
June 15, 2023	F-12	F	Pole camera examination	Rodent	Squirrel	Operational	No. The box was in use	Droppings inside the box
June 17, 2023	F-13	F	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	Potentially three nestlings and 2 eggs
June 14, 2023	F-14	F	NA	Not Found	NA	Gone	Not Found	Not found, potentially under blowdown
June 15, 2023	F-16	F	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest inside. Mainly moss with some grasses and feathers
June 15, 2023	F-19	F	Visual inspection	Unknown	NA	Operational	No. Not inspected due to wasp attack	Wasp nest active. Not surveyed, we had to ran away from the site
June 15, 2023	F-20	F	Pole camera examination	No	None	Operational	Nest material added	-
June 19, 2023	F-21	F	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	Old nest. No signs of eggs or nestlings. The nest had a lot of snake carcasses
June 14, 2023	F-22	F	Pole camera examination	No	None	Operational	Nest material added	-
June 15, 2023	F-23	F	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nesting attempts. Some bark, grasses and moss scattered. New nesting material added
June 15, 2023	F-24	F	Pole camera examination	Rodent	Flying Squirrel	Operational	No. The box was in use	Squirrel nesting inside the box. Squirrel was not evicted
June 19, 2023	F-26	F	Pole camera examination	Yes	Goldeneye	Operational	No. The box was in use	2 eggs. Potentially Goldeneye
June 18, 2023	F-27	F	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	Nest was left intact
June 18, 2023	F-27	F	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	Nest was left intact (AMKE)

2023 Monitoring Date	Nest Box ID	Nest Box Type	Survey Methods	Current Use	Bird Species Using Box	Box Status	Maintenance Completed	Comments
June 14, 2023	F-28	F	Pole camera examination	No	None	Operational	Nest material added	-
June 14, 2023	F-30	F	Pole camera examination	No	None	Operational	Nest material added	-
June 17, 2023	F-33	F	Visual inspection	Yes	American Kestrel	Operational	No. The box was in use	One egg found while inspecting the box visually. It was too dark for the endoscope to detect the egg
June 18, 2023	F-35	F	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	One egg observed with the endoscope. Nest was left intact
June 19, 2023	F-36	F	Pole camera examination	No	None	Operational	Nest material added	New nesting material added
June 19, 2023	F-38	F	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	4 nestlings inside the box. Adult left the box when we were approaching the site
June 15, 2023	F-40	F	Visual inspection	Yes	Unknown	Operational	No. The box was in use	Nest inside. The nest has a base of moss (potentially an old nest) and a top thick layer of large leaves (birch)
June 19, 2023	F-41	F	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	3 eggs inside the nest box with some white downy feathers around
June 17, 2023	F-43	F	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	Adult flew when we inserted the endoscope In the box
June 17, 2023	F-43	F	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	Adult flew when we inserted the endoscope In the box
June 17, 2023	F-45	F	NA	Damaged	NA	Non operational	No. It needs major repairs	Box was destroyed by a bear. Impossible to repair on site
June 19, 2023	F-46	F	Pole camera examination	Rodent	Red Squirrel	Operational	No. The box was in use	Box is being used by red squirrel
June 15, 2023	F-47	F	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Moss nest inside
June 15, 2023	F-47	F	Visual inspection	No	None	Operational	Nest material added	-
June 19, 2023	F-48	F	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	Nest was left intact
June 19, 2023	F-48	F	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	Nest was left intact
June 19, 2023	F-49	F	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest was left intact. No new nesting material added
June 17, 2023	G-01	G	Pole camera examination	No	None	Operational	Nest material added	-
June 15, 2023	G-03	G	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest inside (mainly moss). Potentially in the making. No new nesting material added
June 19, 2023	G-04	G	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	-
June 18, 2023	G-06	G	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Nest inside. Nest was left intact. No nesting material needed
June 15, 2023	G-065	G	Visual inspection	Yes	Unknown	Operational	No. The box was in use	Nesting attempt: some moss and grasses scattered in the box
June 15, 2023	G-08	G	Pole camera examination	No	None	Operational	Nest material added	-
June 19, 2023	G-09	G	NA	Damaged	Unknown	Non operational	No. It needs major repairs	The box was damaged by a bear potentially early in the season or last year. The box cannot be repatriated with the tools at hand. More wood is needed to repair the top front and back and mesh inside
June 19, 2023	G-10	G	Pole camera examination	Yes	American Kestrel	Operational	No. The box was in use	One dead AMKE (adult) Inside the box
June 19, 2023	G-12	G	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Old grass nest inside
June 19, 2023	G-14	G	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	Moss and grass nest inside. Bottom of the box was down. Bottom was temporary fixed, but some additional reinforcements are needed
June 18, 2023	OWL-02	OWL	Pole camera examination	Yes	Unknown	Operational	No. The box was in use	One grass nest inside. There was a sparrow chirping a lot around the box (potential protective behaviour)
June 18, 2023	OWL-03	OWL	NA	Not Found	NA	Gone	Not Found	Not found

Appendix 12. Wildlife Tress Habitat Enhancement 2023 Final Report

Enhancing Habitat for Wildlife Tree Dependent Species in the Site C Project Area: Project No. 4500048244

Year 2 (2023) Final Report

Prepared by: Todd Manning (MASc, RPBio., RPF, QEP)

Strategic Resource Solutions (SRS)

Victoria, BC

March 25, 2024

1.0 Background: The Importance of Wildlife Trees

Dead wood contributes to biological richness as substrate, cavity sites, foraging sites, and shelter or cover. In the Pacific Northwest, 69 vertebrate species commonly use cavities, 47 species respond positively to downed wood, and prevalence of both standing dead and downed wood is related to natural fire regimes and other disturbance agents (Bunnell et al. 2002). Selection of both cavity and foraging sites is governed by decay patterns.

Dead and dying trees (a.k.a. wildlife trees) provide critical nesting, denning, roosting, and feeding habitat for more than 70 species of birds, mammals, and amphibians in British Columbia (B.C.), including some species that are considered at risk provincially and federally. Depending on the age, condition, and disturbance type and history of the forested landscape, wildlife trees can be in short supply in some areas. This is the case in various areas within the Peace-Williston and Site C reservoir footprint areas. Medium- to large-diameter trees that contain heart rot decay are selectively used by up to 40 species (21%) of birds and mammals in the Boreal White and Black Spruce biogeoclimatic zone of northeastern BC (Fenger et al. 2006, Bunnell et al. 2002); these include various woodpeckers and sapsuckers [including the keystone species Pileated Woodpecker (*Dryocopus pileatus*) and neotropical migrant Yellow-bellied Sapsucker (*Sphyrapicus varius*)], some owls and the migrant American Kestrel (*Falco sparverius*), some ducks including buffleheads and goldeneyes (*Bucephala spp.*), and some neotropical migrant passerine birds [e.g., tree swallows (*Tachycineta bicolor*), house wrens (*Troglodytes aedon*)]. In addition, mammals including various bats and furbearers [e.g., red squirrels (*Tamiasciurus hudsonicus*) and northern flying squirrel (*Glaucomys sabrinus*), marten (*Martes americana*) and fishers (*Pekania pennanti*)], use wildlife trees for denning, nesting, roosting and feeding.

Numerous researchers have concluded that wildlife trees show evidence of internal decay (e.g., presence of fungal heart rot conks). For example, in an analysis of nest tree selection by primary cavity excavators in south-central BC, Keisker (1987) found that only 10% of available (potential) nest trees (either trembling aspen (*Populus tremuloides*) or paper birch (*Betula papyfera*) had conks, but conks were present on 70% of the trees used for nesting (n=243). This represented a significant preference for nesting in trees bearing fungal conks for all bird species observed, with a tendency for cavity nesting bird species to prefer trees with broken tops over intact trees.

In a seminal study of heart rot decay in trembling aspen (n=1754), Basham (1958) found that approximately 90% of such decay (primarily from the fungus *Phellinus tremulae*) could be traced to an entrance at dead, broken branch stubs and other visible trunk wounds. And in an analysis of woodpecker nest tree selection and characteristics in trembling aspen stands in the Dawson Creek Forest District, Manning et al. (2001) found that "…96% of all nest trees had fungal conks present and some level of heartwood decay.

In current stands containing suitable fisher habitats in the Fish and Wildlife Compensation Program Peace Region footprint area, naturally occurring trees likely to be suitable for fisher denning are relatively scarce, averaging 0.273 trees/ha (Simpson et al. 2013). Trees likely suitable for fisher denning are referred to as Tier 3 trees, and are trembling aspen ≥ 45 cm dbh or balsam poplar (*Populus balsamifera*) ≥52 cm dbh, with existing entrance 5 – 10 cm wide at the narrowest axis leading to advanced decay within the tree stem. Those Tier 3 trees averaged 48 cm dbh for trembling aspen and 71 cm dbh for balsam poplar (Simpson et al. 2013).

2.0 Project Objectives and Benefits

The main objective of this project was to evaluate the ecological effectiveness of using fungal inoculation and mechanical treatments for the creation of wildlife trees within a controlled experimental context. Thus, the project objectives and associated benefits were to:

1) Increase nesting and denning habitat supply for wildlife tree-dependent species near the Site C Reservoir footprint. Pileated Woodpecker and fishers, for example, are both keystone wildlife species, and fisher and marten are of commercial importance. Treated wildlife trees will also provide nesting and roosting habitat for other woodpeckers, owls, migratory passerines and kestrels, squirrels and bat species; and

2) Increase knowledge of wildlife tree recruitment and forest structure/habitat supply enhancement methods and results.

3.0 Study Area

The approximate locations of sites selected for wildlife tree recruitment and enhancement treatments are shown in Figure 1. These sites are located along the Peace River corridor west of Fort St. John, BC, and are primarily lower elevation, mature mixed wood stands within the Boreal White and Black Spruce Moist Warm (BWBSmw1) and Sub Boreal Spruce Wet Cool (SBSwk2) biogeoclimatic subzone variants (Andrusiak and Simpson 2012); these stands are typically characterized by mesic to wet, nutrient rich site conditions, often with a riparian association (Andrusiak and Simpson 2012; Meidinger and Pojar 1991). The climate is moderate and continental, with moderately warm summers and relatively cold winters. The most common tree species are balsam poplar, trembling aspen, white spruce (*Picea glauca*), balsam poplar, black cottonwood (*Populus balsamifera trichocarpa*), lodgepole pine (*Pinus contorta*) and paper birch.

In general, all treatment sites were located in areas of intermediate and mature seral forest, providing flexibility in site selection and containing some large diameter balsam poplar, trembling aspen and black cottonwood trees. Treatment sites in 2023 (Year 2) were located on the south side of the Peace River, east of Hudson's Hope, BC (see Figure 1), with access from the Medicine Woman Forest Service Road (FSR) near Moberly Lake, BC. Confirmation of the sites treated in 2023 was made via a combination of forest cover inventory and habitat suitability mapping (where available) review, along with site visits conducted by the author in July 2023. Direct site reconnaissance in this manner prior to conducting tree treatments was essential to assess stand structure and tree species composition and size, as well as suitable road access.

Additional variables that influenced treatment site selection were stand size, condition and integrity (i.e., at least 4 ha in area in order to provide forest interior conditions and minimize edge effect and fragmentation), and the abundance and spatial distribution of suitably-sized trees for treatment at each site (see Section 4.1).

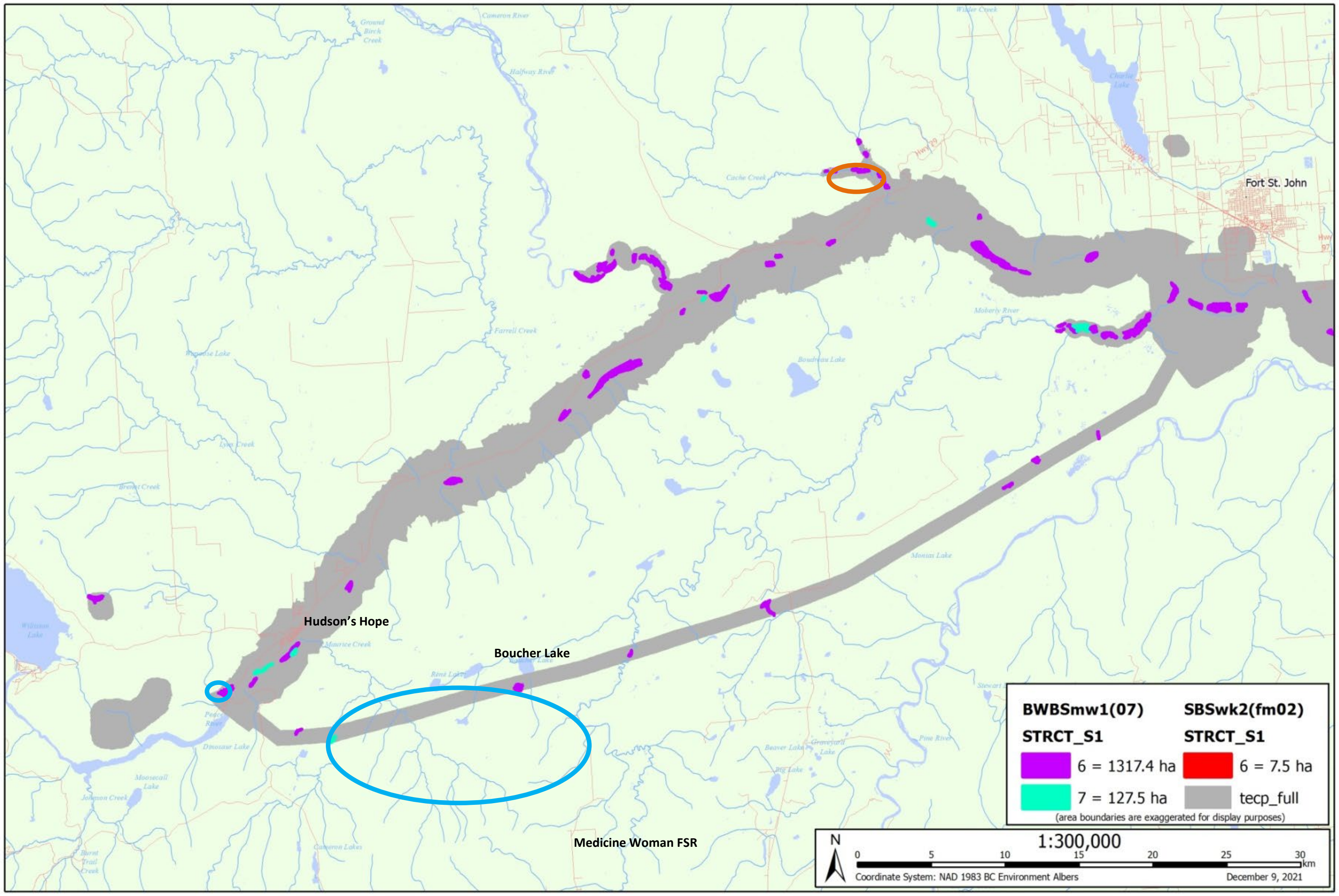

Figure 1. Map view within the general Site C project footprint area showing mature and old structural stage forest polygons dominated by balsam poplar, trembling aspen, white spruce and cottonwood. These sites fall primarily within the BWBSmw2 biogeoclimatic subzone variants. Orange oval indicates the approximate location of the 2022 wildlife tree treatments (to the west of the Halfway River, with access at 4.5 km Swanson Road; n=120 trees), while the two blue ovals indicate the approximate locations of the 2023 wildlife tree treatments (near the Peace Canyon Dam south of Hudson's Hope, and north of Moberly Lake, with access from Medicine Woman FSR; n=180 trees). Note: "*tecp_full*" (grey shading) indicates geographic extent of the "Terrestrial Ecosystem Corridor Mapping Project" (Andrusiak and Simpson 2012).

4.0 Methods

Tree treatments were conducted at the Medicine Woman FSR field site (see Figure 1) from Oct. 13-20, 2023. A 4-person SRS arborist crew and professional biologist (T. Manning) worked on site during this period and completed creation/enhancement of 180 wildlife trees. Descriptive data for each tree [i.e., tree species, tree diameter at breast height (dbh), treatment type (e.g., tall stub, modified window with bat roosting or fisher denning habitat features), species of fungal inoculant applied, post-treatment photograph, and tree location (UTM)] were recorded and stored on a handheld iPad device using the mapping/data collection software *Avenza Maps* (v. 3.15.5). In addition, all treated trees were physically marked in the field with small aluminum tags (numbered 001-300) to aid future identification and monitoring (Figure 2).

Three general types of wildlife tree treatments were conducted in 2023 at the Site C project area (n=180 trees). These were "window treatments", "tall stub" treatments (with stem modifications applied for fisher denning and bat roosting), and two types of control treatments. These treatments are described in sections 4.2, 4.3 and 4.4 below. Similar treatments conducted at the Site C project area in 2022 (n=120 trees) are described in Manning (2023).

A summary of these treatments is provided in Table 1. Additional more detailed descriptive tree data on each individual treated tree is provided in Appendix 1 (i.e., tree number, date, location (UTMs), tree species, tree diameter, treatment type, fungal inoculant applied; *provided as a separate companion document*).

Figure 2. Wildlife tree (larger diameter, mature trembling aspen) which received a fisher den treatment and with a numbered aluminum tree tag (#128) attached to the lower stem (Oct. 2023).

4.1 Additional criteria for candidate tree selection

Trees selected for any of the wildlife tree creation treatments described below also had the following initial characteristics or conditions at the time of treatment:

a) Live trees with no visible external damage or evidence of existing internal decay [e.g., no broken top, large stem scar, large stem crack or open cavity, no fungal fruiting bodies (unless specifically noted for comparative monitoring purposes), no woodpecker cavities and excavations].
b) Live trees with diameter at breast height (outside bark) >40 cm for bat roost tree habitat creation. For fisher den tree treatments, candidate trees include trembling aspen with minimum diameter ≥ 45 cm dbh, or balsam poplar/black cottonwood >52 cm dbh (Simpson et al. 2013).
c) Candidate trees suitable as habitat for primary cavity excavators (i.e., woodpeckers and sapsuckers) and some secondary cavity-dwellers (e.g., small owls), should have diameters of ≥30 cm dbh (Manning and Manley 2014); these trees do not receive stem modifications specifically intended as fisher dens or bat habitat features.
d) Live trees with few limbs in the lower ½ of the tree bole. Such trees make good candidates for tall stub treatments.
e) Live trees with natural live forked tops or multiple tops. Such trees (if present) can have one or more of these tops removed or shortened as part of dead top treatments.

Where available, candidate trees selected for treatment were located in mature structural stage 6 (80-140 years) forest stands [BWBSmw1 (site series 07) subzone variants – White Spruce-Currant-Horsetail plant association]. These site series were dominated by larger-sized balsam poplar, trembling aspen and white spruce, with minor components of black cottonwood (Andrusiak and Simpson 2012) and provided suitable nesting and denning habitat for various cavity-dwelling species, including woodpeckers, bats and furbearers (squirrels, marten and fisher). In some cases where the quantity (i.e., abundance of trees, areal extent or degree of fragmentation), quality (i.e., abundance/availability of suitably sized candidate trees), or site access were poor or limiting, then treatment sites were located in "early mature forest" which may not have been previously mapped as structural stage 6. Such stands should have displayed mature forest characteristics including the presence of some larger diameter stems (i.e., > 40 cm dbh) with minimal stand fragmentation.

4.2 Window Treatments

Window treatments involve modifying a 2-4 metre (m) section in the lower-middle portion of the bole (at approximately 2-10 m above ground), then applying three, half-circumference stem ring girdles on the same side of the tree bole (intended to stress the tree but not kill it, and more importantly to reduce sap flow and sapwood moisture content in the portion of the stem between the lower and upper girdles). Reducing stemwood moisture enhances colonization by fungal organisms (Boddy 2021). Window treatments were inoculated six times with native heart rot fungus[1]. Window treatments remain as live trees post-treatment and were applied specifically for bat roosting or fisher denning in 2023, and are described below.

[1]Appropriate fungal organisms which had been cultured *a priori* in the laboratory on 8 cm long x 1.3 cm diameter wooden dowels, were inserted into the inoculated tree treatment types (i.e., Windows, Tall stubs or inoculated-only Controls). For further information on relevant laboratory methods, see Manning and Manley (2014).

Bat Roosts

Window treatments can provide immediate roosting opportunities for bats and when inoculated with appropriate heart rot fungi, stem decay and subsequent development of larger internal cavities for maternity roosting is facilitated. Dependent on site-specific habitat suitability (i.e., location of the treated tree in relation to solar exposure, proximity to open foraging sites, and crown canopy closure), bat-specific habitat features were added to the portion of stem between the girdles. Such habitat features included two plunge cuts (Figure 3) plus a simulated lightning strike/vertically running stem crack (Figure 4), and were applied at relatively low heights[2] above ground level (i.e., 2-6 m). Otherwise, the remaining majority of the tree bole is left undamaged thereby maintaining a live tree which can provide long term habitat supply. Bat roost treatments were applied either near the base of selected trees as window treatments (tree remains alive and is inoculated six times with one of the two fungal species named below), or higher up the stem as part of a tall stub treatment (inoculated nine times, see Section 4.3 below). These tall stub trees will also function as future nesting and foraging habitat for various primary cavity excavating birds (e.g., woodpeckers). One-half (10/20) of the bat roost trees created in 2023 were not inoculated as they formed part of the control treatment sample size described below (see Section 4.4). For bat habitat feature-treated trees which were inoculated with native heart rot fungus in 2023, *Fomes fomentarius* or *Phellinus tremulae* (trembling aspen only) were used as fungal inoculants.

Figure 3. Close-up view of a bat feature "plunge cut" applied to the trunk of a treated tree.

[2]Northern Myotis (*Myotis septentrionalis*) maternity roosts have been recently documented in the Peace Region only a few meters above ground, and almost exclusively in basal stem wounds on larger diameter, live trembling aspen (B. Paterson pers. comm., independent wildlife biologist, Dawson Creek, BC.).

Figure 4. Large diameter black cottonwood with bat habitat features (two upwardly angling plunge cuts at red arrows and one simulated lightning strike/crack at blue arrows) applied to the live stem. This tree was not inoculated nor stem girdled, and remains as a live tree. The vertically running stem crack is relatively narrow (~2 cm) and deep (~15 cm), running approximately 1 m in length. This treatment is intended to provide immediate roosting habitat for Northern Myotis (*Myotis septentrionalis*).

Fisher Dens

All fisher den treatments are considered "low height window treatments" and were inoculated six times with one species of heart-rot fungi (either *F. fomentarius*, *Ganaderma applanatum, Phellinus igniarius*, P. *tremulae* or *Spongipellis delectans* (black cottonwood only) to create a future internal decay column of sufficient size for denning. Fisher natal den cavity entrances are known to be quite specific in dimension, being relatively narrow at approximately 5-10 cm wide x 7-15 cm tall, and usually 3-7 m above ground (BC Fisher Habitat Working Group 2020; Simpson et al. 2013). It is likely that both the size and height of den cavity entrances is important for excluding potential predators (Lofroth et al. 2010). Consequently, cavity entrances mimicking these dimensions were applied to treated fisher den trees (Figure 5).

Double ½ circumference lower stem girdles and elongated stem cracks which extended approximately 15 cm into the heartwood in an "X" pattern, were used in 2023 on fisher den treatment trees (also see Figure 5). This minor modification was implemented as a means of further reducing the moisture content of the sapwood and heartwood layers in the treated stem section near the constructed den cavity entrance, by endeavouring to sever the medullary rays which contain water conducting vessels (xylem) and ray parenchyma tissue which extend radially inward from the outer xylem to the inner heartwood (Boddy 2021). Reducing cell moisture and increasing aeration in the sapwood and heartwood are contributing factors to successful fungal colonization (Wainhouse and Boddy 2022; Boddy 2021; Boddy and Rayner 1983).

4.3 Tall Stub Treatments

Tall stub treatments involve full-girdling the tree below the lowest live limbs (i.e., generally at 4-8 m above ground), and inoculating above this point with any of the native heart rot species *Ganoderma applanatum, Fomes fomentarius, P. igniarius* (on black cottonwood only), *P. tremulae*, *Fomitopsis pinicola* or *Spongipellis delectans*. Tall stub trees are topped at approximately 8-15 m height with the intention to kill the tree, leaving a moderate-height, standing dead tree (i.e., a stub tree; Figure 6) which will develop heart rot decay relatively quickly, as well as natural sap rot decay in the outer sapwood. The result is an ecologically functional (useable) standing dead tree in the near term, providing short-medium term habitat supply and woody substrate for feeding and excavation of nesting, roosting or denning cavities.

Tall stub trees are inoculated nine times with one of the fungal species named above, although *G. applanatum* and *F. fomentarius* were used for the majority of tall stub treatments due their ability to rapidly colonize and decay dead wood tissue (Callan 1998; Allen et al. 1996). Additional habitat features for bats (i.e., plunge cuts and simulated lightning strikes and vertical stem cracks, as described above) were added to many of the tall stub treatment trees.

4.4 Control Treatments

As in 2022, and also as specified per the project mitigation and monitoring program (BCH 2023), two types of control treatments were applied in 2023. These involved: i) fungal inoculation (with 9 cultured dowels) of trees without any mechanical stem modifications such as topping or girdling; and ii) mechanical stem modifications only (i.e., topping and girdling to create a tall stub) without fungal inoculation; some mechanical-only treatments also received bat habitat features (plunge cuts and simulated lightning strikes/stem cracks).

For further detailed information on the overall treatment regime (project study design), refer to BC Hydro (2023).

Figure 5. Fisher den tree treatments applied to large diameter trembling aspen (Oct. 2022 at left; Oct. 2023 close-up view at right). Note the rectangular-shaped den cavity entrance (red arrows), two partial (1/2-circumference) stem girdles at the blue arrows, and five (5/6) of the inoculant dowel drill holes just above the purple arrows. Also note the two diagonally running (X pattern) “stem slices” at the black arrows, extending radially inward and along the length of the applied stem scar between the cavity entrance and lower stem girdles.

Figure 6. Tall stub treatment applied to a black cottonwood (Oct. 2023). This taller remaining dead stem can provide future foraging and nesting habitat for primary cavity excavating birds and other secondary cavity dwellers (e.g., small forest owls). Note full-stem ring girdles at red arrows which ensure that this tree will remain as a standing dead tree. Also note superficial “stem scuffs” (at green arrows) applied to the tree as visual stimulants to attract primary cavity excavating birds. Tall stub treatments such as this tree are inoculated 9x within the segment of the stem above the girdles, with the appropriate heart rot decay fungus (e.g., *Spongipellis delectans*, *Phellinus igniarius* or *Fomes fomentarius*).

5.0 Results – 2023 (Year 2)

One-hundred-eighty (180) trees were treated in 2023; the majority (139/180, 77%) were trembling aspen, along with 39 black cottonwood and two balsam poplar. There were very few suitably-sized poplars at the 2023 field sites as most were <30 cm dbh; however, larger-sized aspen and cottonwood were relatively abundant and well distributed throughout the area. Overall mean diameter (dbh, outside bark) of the treated trees (N=180) was 41.9 cm, with a range of 29.0-76.0 cm. A summary of these treatments is provided in Table 1 below.

Thirty trees received treatments for fisher dens and had a mean dbh of 59.7 cm (range 42.0-76.0 cm). Twenty-two trees received treatments for bat roosts and had a mean dbh of 47.7 cm (range 33.0-68.0 cm). Forty trees were control treatments, with 22 of these inoculated only and 18 trees mechanically modified (i.e., tall stub treatment with stem girdling but not inoculated; eight of these trees also received bat habitat feature modifications). The remaining treated trees (88/180, 49%) in 2023 were tall stub treatments with fungal inoculation (as per the methods described in sec. 4.3), and were intended to provide decaying wood habitat for various cavity-dwelling wildlife; as well, eight tall stub treatments received bat habitat feature modifications.

Table 1. Wildlife tree treatments completed at the Site C project area in 2022 and 2023 (refer to Manning 2023 for further detail on the 2022 (Year 1) tree treatments).

Treatment	Tree Species	2022	2023	Description
Window (Bat features)	Black Cottonwood	5	4	Applied to live trees in the lower-mid bole region; these trees remain alive post-treatment.
	Balsam Poplar	5	0	
	Trembling Aspen	0	18	
Window (Fisher dens)	Trembling Aspen	18	23	Applied to live trees in the lower bole region (3-7 m above ground); these trees remain alive post-treatment. Trees inoculated 6x with appropriate fungal species.
	Black Cottonwood	0	7	
Tall Stub	Trembling Aspen	24 - no bat features 30 - with bat features	80 - no bat features 8 - with bat features	A standing dead tree is created, generally 8-15 m in height after treatment. These can function as dead tree habitat supply for a variety of primary and secondary cavity dwelling wildlife. A subset (38 trees over the two year project period) received additional bat habitat features.
Control Treatments (a & b)**	Trembling Aspen	(14+5)[a] + 18[b]	14[a] + 17[b]	[a] Mechanical stem modifications only. No fungal inoculant. [b] Fungal inoculation only. No mechanical stem modifications. ** All a & b control treatments were implemented as tall stubs.
	Balsam Poplar	1[a]	1[b]	
	Black Cottonwood	0	4[a] + 4[b]	
TOTALS	**2022: n=120** 82 treated 38 controls (18 fisher, 40 bats)	**2023: n=180** 140 treated 40 controls (30 fisher, 30 bats)		Total number of trees treated over the two year project period (2022-2023): N=300, which includes 48 fisher den trees, 70 bat roost trees, and 78 control trees.

6.0 Discussion

The wildlife trees created at the Site C project area during 2022 and 2023 with bat feature modifications (stem cracks and small cavities (plunge cuts)) will provide immediate habitat supply for roosting bats. In the near term (i.e., 2-5 years), it is predicted that internal heart rot decay will advance in the inoculated trees, providing additional nesting and foraging habitat for primary cavity-excavating birds (i.e., woodpeckers and sapsuckers). Over the longer term (i.e., 6+ years), heart rot decay should continue to advance, particularly in the inoculated trees, and provide habitat for both primary and secondary cavity-dwelling wildlife, including denning for furbearers (marten and fisher) and maternal roosting opportunities for bats, which both require larger internal tree decay/cavity volumes.

Support for the above forecasts is borne out by the effectiveness monitoring results from similar wildlife tree creation treatments conducted elsewhere in BC. For example, Manning (2023a), Manning (2021) and Manning and Manley (2014) have all documented feeding and nest cavity excavations in inoculated trees by woodpeckers within 2-10 years after treatment. In this context, inoculated tall stub-treated trembling aspen and Ponderosa pine (*Pinus ponderosa*) have consistently shown the most rapid onset of decay and subsequent use by wildlife. Other treated tree species (e.g., Douglas-fir (*Pseudotsuga menziesii*) and western larch (*Larix occidentalis*)) have clearly shown evidence of decay and wildlife use, but not yet to the same extent or as quickly as ponderosa pine and aspen. Other treated tree species such as white spruce, grand fir (*Abies grandis*) and black cottonwood have not yet been sufficiently monitored post-treatment.

Looking at a sampling of wildlife tree enhancement projects from elsewhere, Bednarz et al. (2013), in a follow-up destructive sampling program of live Douglas-fir and western hemlock (*Tsuga heterophylla*) trees in western Washington State which had been inoculated 8-9 years previously with the heart rot fungus *Fomitopsis pinicola*, concluded that "…a higher proportion of treatment trees displayed *F. pinicola* conks and mycelia than did (non-inoculated) control trees". They also observed evidence of significantly more (p=0.01) woodpecker excavations and sapsucker foraging holes associated with fungal inoculation treatments than at control trees. And in a recent review of "tree veteranisation" (i.e., making trees with old-age-like characteristics such as internal hollows) projects from Europe and North America, including an in-depth discussion of associated biological/ecological factors (fungal-tree relationships) as well as implementation techniques involving mechanical stem modifications and fungal inoculation, Wainhouse and Boddy (2022) concluded that "…veteranising inoculations can be used to accelerate decay onset and cavity formation in living trees to create habitat for other species. The selection of a specific fungus to elicit a specific response through species association or rate of colonisation is a potentially powerful tool for creating this micro-habitat".

It should be noted that the tree topping and fungal inoculation methods (as per Parks et al. 1996) that were used in the above-noted U.S. project differed notably from those used in this study, and also in recent similar projects conducted elsewhere in BC. For example, results of some of the monitoring work conducted to date (refer to Manning 2023a, Manning 2021, Manning and Manley 2014) have supported ongoing improvements to the wildlife tree treatment methods and techniques used in recent BC projects. These include:

i) the location, number and type of stem girdles and stem cuts (e.g., double or triple partial or full stem girdling cuts, and application of radially inward-extending stem cuts to sever water conducting tissue (xylem and medullary rays) within specific portions of the tree trunk (see Figure 5);

ii) inoculation with multiple cultured wooden dowels (e.g., 3, 6 or 9 dowels grouped in loose clusters of three) within desired segments of the treated stem (as opposed to single dowels installed at various heights on the tree stem);

iii) selecting and using different species of endemic Basidiomycete decay fungi which are relatively tree host specific (i.e., consider intended treatment tree species and live versus dead wood colonizers), and also those fungi known for their ability to successfully and more rapidly colonize the host tree causing heart rot decay (i.e. these include more suitable inoculant fungi such as *Ganoderma applanatum* which are usually K-selected and are better at tolerating adverse internal woody micro-environments which contain defensive organic compounds such as tannins, terpenes and polyphenols, or can better tolerate micro-environments which have higher acidity or wood moisture levels, as well as those which contain other competing fungal and bacterial organisms), versus the application of an fungal inoculant species such as *Phellinus pini* that has been used in other wildlife tree creation/inoculation projects (e.g., Filip et al. 2011) and which is known to be a slow-acting wood decay agent (Manning 2014; Allen et al. 1996); and

iv) leaving the inoculant dowel entry hole (i.e., drilled into the tree stem) mostly plugged with the wooden dowel which better mimics less aerobic, naturally occluding infection courts such as broken branch collar wounds (Manning and Manley 2014); this is unlike earlier treatment methods (Filip et al. 2011, Parks et al. 1996) which kept the wound/dowel entry hole artificially open to the atmosphere[3] by inserting a piece of PVC tubing.

The above four techniques modifications are collectively part of a continuous learning and improvement process implemented by the author, and are intended to better understand the complex relationships between trees, tree wounding, fungal colonization and decay, and subsequent use by cavity-dwelling wildlife.

7.0 Conclusion

In conclusion, the 300 wildlife trees created or enhanced at the Site C project area in 2022-2023 will provide habitat for local cavity-dwelling wildlife species over multiple time scales, including various birds such as woodpeckers and owls, as well as bats and furbearers. As well, the treatments implemented here will increase our knowledge and understanding of forest structure/habitat supply enhancement methods. Thus, the overall objectives of this project have been achieved.

Going forward, it will be important to monitor the treated trees over time (e.g., 3-5 years post-treatment, circa 2025-2027) in order to observe changes in tree condition and assess any use by wildlife. As such, further study may include:

1) the susceptibility of differing tree species to infection and colonization by endemic fungal organisms;

2) the morphological and physiological pathways and dynamics of tree-fungal interactions and wood decay processes at the tissue level (particularly Basidiomycete heart rot fungi); and

3) how improved knowledge and understanding stemming from topics #1 and #2 above, can be used to further improve wildlife tree creation techniques and forest structure enhancement or restoration practices.

[3] It was thought that keeping the drill hole artificially open to the atmosphere would enhance aeration to the adjacent stem wood, thereby enhancing the onset of decay. However, Manning and Manley (2014) and Stamets (2000) have described that vegetative mycelial growth (i.e., leading to wood decay) is favoured by micro-environments with prolonged high CO_2 levels (5%), high relative humidity often at 95–100% (but not high water content, as would be the case in live, functional xylem or phloem tissue), and low or nil ambient light levels.

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Appendix 13. Fisher Den Box Monitoring 2023 Final Report

Site C Clean Energy Project
Wildlife Mitigation
Fisher Den Box Monitoring:
2023 Final Report

February 2024

Prepared for: BC Hydro and Power Authority

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Executive Summary

Fisher den boxes were installed and monitored between 2018 – 2023 in an effort to mitigate impacts of the Site C Clean Energy Project reservoir on fisher reproductive habitat. Fishers require cavities in large diameter trees for reproductive denning and research elsewhere has found that fishers will use den boxes to give birth and raise kits. In 2023, monitoring of the 88 den boxes installed at Site C included visiting all den boxes to install game cameras, checking and replacing hair snaggers at den box entrances, and applying lure at the structures to help attract fishers (February – March 2023). After the reproductive denning season, game cameras were retrieved (August to December 2023), glue strips were checked for hair samples, and trail camera images were reviewed to assess use. A total of 106,946 photographs were reviewed from the 2023 reproductive season (March – July). Fishers were detected at eight den boxes, with two boxes each having two separate visits, and a fisher was observed entering one of the structures on one occasion. However, similar to other years of the project, no prolonged use or evidence of reproduction was observed in 2023. Analysis of hair samples collected from hair snaggers over the course of the project failed to detect any fishers, although DNA from American marten, red squirrels, and black bears were identified using this method. Glue strip hair snaggers were deployed between February – July each year and hardening of the glue is suspected of decreasing the chances of detecting fishers. Despite this, cameras were functional at approximately 97% of den boxes and would have identified any structures actually being used for reproductive purposes.

Past years of the project have had similar results with 0, 1, 0, 2, and 8 boxes having fisher detections between 2019 and 2023. Previous surveys in the Site C area found a very low density of fishers present (5.9 fishers/1000 km^2) and fisher territories in the Boreal Fisher Zone of BC generally have an abundance of cavity trees with potential for reproduction compared to other Fisher Zones in BC. The low density of fishers present in the area and sufficient numbers of natural dens is suspected of contributing to our results, indicating that natural fisher dens may not be a limiting factor in the study area at this time.

These results are from the final year of planned monitoring and recommendations are to conduct periodic surveys of the den boxes at 5-year intervals. Boreal areas in BC have the greatest recorded densities of fishers in the province and the local fisher population may increase over time, further increasing the potential for reproductive use by female fishers. Based on surveys in the last year of monitoring, 87/88 den boxes were still in functional condition for fisher reproductive use. Future surveys can also provide valuable information on the longevity of the structures. Understanding how long the den boxes remain as viable reproductive habitat may aid in conservation efforts for this species.

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1.0 Introduction

Fishers (*Pekania pennanti*) are forest-dependent carnivores in the Mustelidae family that are an important component of healthy ecosystems within their range. Several aspects of the ecology of fishers, including their use of rare structural elements found primarily in late-successional forests (e.g., large diameter trees with cavities used as denning sites), make them susceptible to changes to the forested land base. Loss of forest habitat is thought to be the primary threat to fisher populations across their range (Proulx *et al.* 2004). Forest harvesting typically removes the features that fishers rely upon for reproduction and resting and replaces them with stands that have fewer of the structural components found in older forest (Yoshida *et al.* 2017, Edworthy and Martin 2013, Goodburn and Lorimer 1998, Weir 1995, Hansen *et al.* 1991). As such, fishers are considered a species at risk under the British Columbia (BC) Identified Wildlife Management Strategy (IWMS). Within BC, fishers have been divided into two distinct populations based on genetic differences (BC Conservation Data Centre 2020). The Boreal fisher population, found in the Peace Region, is provincially blue-listed and has a conservation status ranking of S3 (Special Concern), while the red-listed Columbian population, found in the Central Interior, has a status ranking of S2 (Imperiled) (BC Conservation Data Centre 2020).

Fishers are the largest obligate tree-cavity user in North America, requiring trees that have cavities >30 cm inside diameter as reproductive dens during the rearing period (Weir and Corbould 2008). In BC, reproductive dens are found in large-diameter black cottonwood (*Populus balsamifera ssp. trichocarpa),* balsam poplar (*Populus balsamifera*), trembling aspen (*Populus tremuloides*), lodgepole pine (*Pinus contorta*), and Douglas-fir (*Pseudotsuga menziesii*) trees (Weir and Corbould 2008, Weir 2009, Davis 2009)[1], which are most common in late-successional ecosystems (Lindenmayer *et al.* 2012). The recruitment of suitable fisher den trees is limited, especially where forest harvesting removes mature stands and veteran trees, and these critical habitat elements have become increasingly rare across much of the provincial range of fishers (Weir 2009, Calabrese and Davis 2010, Davis 2012, Weir *et al.* 2012).

A decrease in the supply of suitable den trees may affect the ability of landscapes to support sustainable populations of fishers. Experimental manipulation of cavity abundance in BC found that tripling the abundance of cavities using nest boxes resulted in a comparable increase in the total density of bird and mammal nests (Aitken and Martin 2012). Similarly, the addition of nest boxes in temperate forests of Mexico resulted in increases in the number of secondary cavity nesting birds in both mature and young forests (Lima and Garia 2016). Research in the United Kingdom where the supply of natural denning habitat is low has found that artificial den boxes were used by pine marten (*Martes martes*) for reproduction in managed forests (Messenger *et al.* 2006, Croose *et al.* 2016). Similarly, Davis (2020) found that fishers will also use an artificial den box to give birth to and raise their young in the BC Central Interior.

1.1 Objectives

To help mitigate the impacts of habitat loss on fisher habitat associated with the creation of the Site C reservoir, BC Hydro has installed 88 reproductive den boxes. The den boxes are intended to help replace

[1] BC Fisher Habitat Working Group. British Columbia Fisher Habitat and Forestry Web Module. Accessed December 10, 2023 at https://www.bcfisherhabitat.ca/.

reproductive denning habitat that will be lost during flooding of the reservoir. In the fall of 2018, an initial 10 den boxes were installed and monitored south of the Peace River adjacent to the Site C reservoir footprint following methods outlined in Davis and Horley (2015) (Appendix 1) and monitored by Golder Associates Ltd between 2019 – 2020 (Golder and Associates 2019, 2020, 2021). Subsequently, in the winter of 2019 / 2020, BC Hydro installed 78 additional den boxes in other areas adjacent to the reservoir footprint on both the north and south side of the Peace River corridor that were constructed and monitored by Davis Environmental Ltd (Davis and Paterson 2020). The second group of 78 den boxes were redesigned to reduce the structure's weight and improve installation efficiency while maintaining critical aspects of the structures, such as interior size, insulation, and entrance dimensions, thought to be important for use by female fishers. Davis and Paterson (2020a) provide a description of the redesigned den boxes, installation procedures, photographs, and a summary of den box locations. Monitoring of the 78 structures occurred between 2020 and 2023 and monitoring of the initial 10 den boxes between 2019 and 2023. This report describes the methods and results from monitoring all 88 den boxes during the 2023 reproductive season, a summary and discussion of results over the 5-year period that the structures were monitored, and recommendations for future monitoring.

1.2 Study Area

The study area is located within the Peace River Basin Ecoregion between Hudson Hope and Fort St John (Demarchi 1996). The area is relatively flat, consisting of rolling plains, plateaus, and lowland areas with elevations ranging between 410 – 800 m. The Peace River bisects the area in an east – west direction, with smaller watercourses such as the Moberly River, Cache Creek, and Halfway River feeding into the Peace River Valley. The Boreal White and Black Spruce moist warm (BWBSmw) biogeoclimatic subzone covers the entire study area, with trembling aspen dominating most forest stands (Delong 1990). Balsam poplar occurs on wetter sites along with white spruce. Drier sites have lodgepole pine as a seral species, while black spruce and tamarack occur on organic soils. Most of the lowland habitats on south facing slopes have been converted to growing agricultural crops (Delong 1990).

2.0 Methods

Equipment and materials used in this program included trail cameras, a scent dispenser daubed with fisher lure (combination of Hawbakers Fisher Lure, Sharpes Beaver Castor, aniseed oil, and skunk essence mixed with glycerin), and a glue-strip hair snagger. Den boxes were installed with the opening oriented in a southerly direction to avoid situations where the trail camera would be taking photos into bright sunlight. Reconyx Hyperfire 2 trail cameras were attached to trees approximately 3-5 m from each den box, secured with a Python Lock (Master Lock), and were programmed to record three images at every trigger event, with trigger events separated by 30 s and individual photos separated by 1 s. A medium-high sensitivity setting was used for all cameras. In the last two years of the study, several Reconyx cameras failed and were replaced by Bushnell Trophy Cam HD (4 in 2023 and 3 each in 2022 and 2021). SanDisk 128 GB SD cards and Energizer Ultimate lithium AA batteries were installed in all cameras. A unique den box number (e.g., D40) was assigned to each den box and entered into the corresponding game camera. Each structure also had the den box number written in black felt pen on the side facing the camera. The hair snagger consisted of a 15 mm by 60 mm strip of mouse glue board trap (glue strip) fastened inside the top of the entrance with 19 mm long pan head screws.

Two annual monitoring visits were scheduled: one winter visit in January to early March prior to the beginning of the denning season, and one summer / fall visit after July when juveniles were able to travel with their mothers (Aubry and Raley 2006). Winter visits involved setting up trail cameras, applying fisher lure to a scent-wicking pad attached to the den box, monitoring the structures for signs of fisher use (i.e., tracks, hair, feces, claw marks) or damage, and replacing the hair snaggers / collecting samples from glue strips that had fur attached to them.

Summer / fall visits also included monitoring for signs of fisher use, replacing hair snaggers, removing trail cameras, and recording any signs of damage to the den box, with repairs made as needed. Each glue pad containing a hair sample was removed, covered with plastic paper (Rite-In-Rain), and stored in a paper coin envelope under dry conditions until ready for processing by a laboratory. After the summer / fall monitoring visit, the pictures recorded between the date of camera installation and July 31st were analyzed to determine wildlife use of the boxes. Hair samples collected at the structures between 2020 – March 2023 were sent to a commercial genetics laboratory[2] in May 2023.

3.0 Results

Trail cameras were reinstalled at all den boxes between February 26th and March 5th and were removed between October 2nd and December 20th, 2023. Images recorded over the period between installation and July 31st were analyzed to assess use by mustelids prior to and during the reproductive denning season (i.e. https://www.bcfisherhabitat.ca/, the denning season is generally April – July). Two cameras failed to record images despite having viable batteries, one camera was missing during the fall monitoring visit, and one additional camera only recorded 9 photographs between March 2nd and 27th and none after that despite appearing to be functional during the fall monitoring visit (Table 1). Over an average of 151 days since installation, 85 cameras recorded 106,946 images at den boxes with functioning cameras (mean = 1258, SE = 320, minimum = 9, maximum = 22,572).

Table 1. Den boxes where camera function was impaired during the 2023 field season.

Camera #	Den box	Issue	# Photographs
67	D14	Card error message on display.	0
100	D20	No photos between March 27th – November 11th, batteries good and camera captured photographs on November 12th when being retrieved.	9
101	D21	No photos taken, camera malfunction.	0
	D97	Camera missing during fall monitoring visit.	0

Fishers were observed at eight den boxes during the 2023 monitoring period with only two boxes having detections on more than one day (Table 2, Photographs 1 – 10, Appendix 1). Most detections were of a fisher on the den box tree or on top of the den box and only one has a photograph of a fisher inside the den box. No evidence of reproductive use was observed at any of the structures. Fishers are a territorial species and given their relatively close proximity, detections at boxes D4, D11, D12, and D107 on the south side of the Peace River and boxes D71 and D69 on the north side likely represent only two different fishers visiting the structures (Appendix 1). As such, the detections in 2023 likely represent 4 - 5 different fishers.

[2] Wildlife Genetics International, Nelson, British Columbia, Canada

Photograph 1. Fisher looking into den box D107 on March 16th 2023.

Photograph 2. Fisher at den box D11 on July 17th, 2023.

Photograph 3. Fisher at den box D12 on May 28th, 2032.

Photograph 4. Fisher at box D28 on July 27th, 2023.

Photograph 5. Fisher at box D4 on July 24th, 2023.

Photograph 6. Fisher at den box D69 on March 6th, 2023.

Photograph 7. Fisher at den box D71 on March 7th, 2023.

Photograph 8. Fisher at den box D71 on March 25th, 2023.

Photograph 9. Fisher at den box D99 on March 3rd, 2023.

Photograph 10. Fisher inside den box D99 on March 26th, 2023.

Table 2. Den boxes with fisher detections at Site C during the 2023 reproductive period (March – July).

Den box	Date and time	# Photos	Comments
D107	16-Mar-23 at 19:59	3	Fisher looks into den box.
D11	17-Jul-23 at 11:47	6	Fisher on den box tree; Smaller fisher, possibly female.
D12	28-May-23 at 16:55	6	Fisher on den box tree.
D28	27-Jul-23 at 5:41	6	Fisher on den box tree; Smaller fisher, possibly female.
D4	24-Jul-23 at 11:57	6	Fisher investigates entrance to box; Smaller fisher, possibly female.
D69	6-Mar-23 at 23:50	3	Fisher on den box tree; appears to be large male.
D71	7-Mar-23 at 0:10	6	Fisher on den box tree.
D71	25-Mar-23 at 2:38	3	Fisher on den box tree.
D99	3-Mar-23 at 1:25	3	Fisher on top of den box.
D99	26-Mar-23 at 1:08	6	Fisher inside den box; Smaller fisher, likely female.

The eight den boxes with fisher detections are a substantial increase from 2022 (2 boxes – D99 and D21), 2020 (1 box – D91), and the zero detections in 2021 and 2019 (Appendix 1); however, no prolonged use of the structures was observed, and photographs indicate that only one den box (D99) was actually entered. Box D99 was also entered in 2022 along with Box D21 which did not detect a fisher in 2023.

DNA analysis results from 92 hair samples collected from the structures between 2019 – 2023 failed to detect any fishers despite being observed using the structures during this period. Other species detected by the laboratory analysis included 37 samples of American marten (*Martes americana*), 38 of red squirrel (*Tamiasciurus hudsonicus*), four of black bear (*Ursus americanus*), one house cat (*Felis catus*), seven were not analyzed due to insufficient genetic material, and five of the samples failed to identify an animal species. We also observed flying squirrels (*Glaucomys sabrinus*) frequently using the structures in every year of the study despite not collecting viable hair samples from this species.

Martens were observed at 28 den boxes in 2023, which is a slight decrease from 2022 (34 boxes) and 2021 (30 boxes) but much greater than 2020 (11 boxes). No marten were observed at the initial 10 den boxes in 2019 but 5 of the boxes had a marten detection in 2020. In 2023, 10 of the 28 boxes had >1 visit with an average of 1.6 detections at each structure (range 1-6) between March and July. We recorded 273 photographs of marten at den boxes exhibiting behaviors such as going in and out of a box (84 photographs) and resting on top of a box (12 photographs). It is important to note that the cameras did not always record every entry and exit, possibly due to the lag time between camera bursts (e.g., cameras were programmed with 30s lag time between bursts of three photographs). These behaviours are consistent with those occurring in 2021 and 2022.

One instance where a marten may have been using a den box for reproductive purposes occurred in 2020 when a marten made prolonged use of den box D73 between May 15 – 21, 2020 (Davis and Paterson 2020). During this period, 80 photographs were recorded with 75 containing a marten regularly going in and out of the den box. Given that photographs are shot in bursts of three, this represents 25 occasions of the marten arriving and leaving the structure over approximately 139 hours (i.e., one occasion every ~5.5 hours). On May 21st at 00:46 a marten was photographed leaving the box carrying a small kit-shaped form. A marten returned and left with a second kit-shaped form at 01:16. At 04:35 the same day, a marten returns to the box with a smaller-sized bundle than the marten was seen leaving with on the previous two occasions and then the marten leaves at 04:45. At 19:00 on May 21st a marten entered again and departed at 19:05. On May 23rd, a red squirrel was photographed entering the den box. Two days later, a marten was photographed leaving the structure. The entry of the box by a squirrel likely indicates that marten use had ceased to be continuous by that point in time.

All den boxes were assessed for condition during the last monitoring visit of 2023. A 5-point scale was used to rate the condition of the structures where a score of 5 was in excellent condition and 0 was unusable (Table 3). The boxes were generally in very good condition with an average score of 4.34 (n=88, SE=0.98). Only one box scored a zero (the tree had fallen) and squirrel chewing was the leading cause of damage on other boxes. Several boxes had chewing damage that extended through the inner layer of plywood but this was only on the boxes with the 9.5 mm plywood (78 boxes installed in 2020) and not the structures with 19 mm plywood (10 boxes installed in 2018). The rigid foam insulation on some boxes has started to break down from what appeared to be insect damage for 15% of the structures; however, this generally only resulted in a 1-point drop in the condition rating.

Table 3. Den box condition rating system and survey outcomes.

Description	Rating	# Boxes
Den box no longer usable (holes in structure >5cm diameter), insufficient walls and insulation to provide thermal protection and/or protection from predators, or box has fallen onto ground.	0	1
Extensive chewing damage, small holes through walls, insulation and predator protection values are compromised.	1	0
Box has extensive chewing damage inside and outside with some through to insulation, but thermal and predator protection values are still intact.	2	4
Box has extensive chewing damage but not through to insulation. Box may have some deterioration of insulation value.	3	10
Box has some minor chewing damage to multiple locations and/or insulation is starting to deteriorate	4	21
Box has minimal chewing damage and insulation is intact	5	52

4.0 Discussion

Fishers have been found to use artificial dens in British Columbia (Davis 2020) similar to pine marten in the United Kingdom (Croose *et al.* 2016). During the last four out of five years of the Davis (2020) study, eight female fishers used nine different den boxes for twelve reproduction events. The Site C results for fishers are much more limited than found in the Central Interior of BC (Davis 2020). Despite using similar den box structures and sampling methodology, the two projects have had very different results that may be the caused by differences between the study areas such as being in different BC Fisher Habitat Zones[1] and having fisher population estimates that differ greatly. The effects of interspecies competition and historic impacts of predator control efforts may also be contributing to the disparity in results between the two studies.

The Site C study area is located in the Boreal Fisher Habitat Zone[1] where fisher home ranges have approximately 36% of a fisher's territory in reproductive stands, while fisher home ranges in other areas of the province generally have a much lower proportion of area in reproductive stands (e.g., 4.9% in the Subboreal and 7.7% in the Dry Zone) despite having similar size home ranges (~30 km^2)[1]. Surveys have identified reproductive stands as having approximately 0.5 potential den trees per hectare in the Dry subzone (Calabrese and Davis 2010, Davis 2012) and similar densities have been found in the Boreal Zone (personal communication with Rich Weir, Senior Biologist, Artemis Wildlife Consultants). It is important to note that this statistic refers to trees with outward characteristics of fisher den trees (species, diameter, rot, and entrance hole size) and not whether the internal dimensions of the cavity are sufficient for reproductive denning. We did not measure the abundance of potential den trees in the project area; however, given that fisher home ranges in the Boreal Zone have the potential for a much greater supply of habitat containing potential den trees, the supply of den trees may not be limiting fisher reproduction in the project area making the den boxes less attractive to female fishers. However, it is important to note that this is not to suggest that denning habitat is oversupplied in the Boreal Zone as it likely also supplies important foraging and resting habitats for reproductive fishers.

A recent study in Minnesota that deployed den boxes to determine if cavity trees are a limiting resource for fishers in that area had similar results to those found here (Joyce 2022). The Minnesota population of fishers has declined by approximately 50% over the past 20 years and are thought to be relatively low in abundance (personal communication with Dr. Michael Joyce, University of Minnesota). That area is also dominated by deciduous tree species and no fisher reproductive use was documented over the two years between installation and 2022 despite fishers being detected at 11% of den boxes. The author suggest that the results supported the hypothesis that the natural availability of den trees was not limiting the fisher population there (Joyce 2022).

Fisher surveys in 2011 and 2012 predicted a density of approximately 5.9 fishers/1000 km^2 in the Site C study area using mark-recapture models[3]. This is a relatively low density compared to studies in other areas of BC (e.g., Boreal: 18.4 fishers/1000 km^2, Weir *et al.* 2011; Sub-boreal: 11.2 fishers/1000 km^2, Weir and Corbould 2006; Dry: 13.1 fishers/1000 km^2, Davis and Weir 2021). Also, most reproductive dens and female fisher detections in the 2011-2012 survey within the Peace River study area were found in locations on the north side of the Peace River where a lower density of den boxes were installed due to private land access restrictions. Den box studies in the Central Interior of BC had the greatest success in locations where there had been prior inventories and the density of fishers was relatively high (Davis and Weir 2021, Davis 2020, Davis 2004). Given this, the low density of fishers in the Site C area documented in 2011-2012, particularly on the south side of the Peace River, may have contributed to the low number of fisher detections at den boxes during this study.

Competition between predators can shape communities and this competition can be pronounced between species with a similar prey base and relatively small differences in body size (Donadio and Buskirk 2006). Fishers and martens are similar in size, but fishers are larger by a factor of approximately

[3] Jones, J. 2018. Mark-recapture estimate of fisher population size and density. Unpublished memorandum prepared for BC Hydro. 4pp.

2-5x based on weight and both species generally consume the same basket of small mammal prey (small rodents to snowshoe hares in size; Smith *et al.* 2023). Studies of competition for food between species generally assumes that the larger species forces a subordinate competitor to alter their dietary niche through interference competition. However, the Smith et al. (2023) study indicates that marten were the superior exploitative competitor for small prey items in areas with both species present, forcing fishers to adjust their niche to larger prey in response. A greater competitive environment for small prey items may influence habitat suitability for female fishers and make areas with relatively high densities of martens less desirable for females rearing kits.

Others have found evidence of spatial segregation between marten and fishers in Alberta (Fisher *et al.* 2013). This study found that the absence of one species significantly explained the occurrence of the other even after accounting for differences in habitat selection between the species. The authors suggest that competition in spatially heterogenous environments may result in this type of spatial segregation at landscape scales (Fisher *et al.* 2013). However, other studies in eastern North America do not support this finding. Researchers in Michigan (Croose *et al.* 2019) found only weak evidence for spatial niche partitioning between marten and fisher , while Evans and Mortelliti (2022) found positive spatial associations between the two species in Maine.

Alternatively, Richard Weir (Senior Biologist, Artemis Wildlife Consultants) has suggested that historic wolf poisoning programs by livestock owners may have differentially impacted fisher and marten populations in the Site C area. Wolf poisoning programs often administered poison to carrion and both fisher and marten scavenge carrion readily (Powell *et al.* 2003). A recent study of fisher and marten visits to artificial scavenging sites (Kautz, 2021) found that fishers displaced martens at scavenging sites, although this displacement was temporary in nature and, numerically, marten visits far exceeded those of fishers. This suggests that poisoning would impact both species similarly; however, due to the larger home range size, poisoning would likely impact fisher populations to a greater extent. Fisher home ranges can be more than 30 times larger than marten home ranges (Powell *et al.* 2003), providing fishers with a much greater chance of intersecting poisoned carrion. In contrast, the small home range size of marten would result in a lower chance of intersecting poisoned carrion and, likely, more portions of the local population in poison free refugium's that allow for more rapid population recovery.

For fishers in the Site C area, it is likely that a combination of the effects discussed here, including the availability of suitable natural den trees in the project area, low densities of fishers, competitive interactions with other predators including marten, and historic factors are interacting to limit the potential for reproductive use of den boxes by fishers in the study area. Ultimately, the low number of detections and use of den boxes by fishers indicates that the boxes may have low utility in providing reproductive habitat in this study area and during this time period. Despite this, Boreal areas in BC have the greatest recorded densities of fishers in the province and the local fisher population may increase over time, further increasing the potential for reproductive use of the structures. It is also important to note that despite the low amount of use by fishers, the frequent use of the boxes by other species, including marten, red squirrels, and flying squirrels, indicates that the structures can provide habitat for other species in the project area while continuing to provide potential reproductive habitat for fishers.

While fishers did not make extensive use of the den boxes, martens were found to be using a relatively high proportion of using the structures during each year of this study. This included one potential reproductive use and photographs of the marten and potential kits were shown to two biologists with research experience on marten (Eric Lofroth, Boreas Ecological and Rich Weir, Artemis Wildlife Consultants). Both biologists thought it was reasonably consistent with their experience and the literature on the timing of marten maternal denning. As stated previously, marten made frequent use of the structures over the course of this project and the den boxes may have potential to provide reproductive habitat for marten in the area.

Overall, the den boxes were in good condition after 3 – 4 years in the field with only one box in 2023 and two boxes in 2021 (Davis and Patterson 2001) rendered unusable for reproduction by fishers. In all three cases, the structures were still in good condition but the trees they were on were felled during wind events. The den boxes in 2021 were reinstalled on adjacent trees while the 2023 box was not reinstalled. Squirrel chewing damage was the other major cause of degradation with several boxes having been chewed through to the insulation on the inside of the structures. The inner lining on the 78 of the structures installed in 2019-20 (Davis and Paterson 2000a) is only 9.5 mm thick compared to the 19 mm thick lining on the 10 boxes installed in 2018 (Golder 2019) and the boxes installed in the BC Central Interior (Davis 2020). This change to the design was implemented to help save weight when installing the structures as all boxes were backpacked anywhere from 50 m to several kilometers (average distance was approximately 250 m) to the installation locations. The change resulted in a 22% decrease in the structures weight (31 Kg to 24 kg). Understanding if this difference in design makes structures with a 9.5 mm inner plywood lining more susceptible to squirrel chewing damage will be important in making recommendations for future den box deployments.

5.0 Conclusions and Recommendations

The fifth year of fisher monitoring for the initial 10 den boxes installed in 2018 and the fourth year of monitoring for the 78 den boxes installed in 2019 and 2020 was completed in the fall of 2023. Fisher detections increased significantly during the last year of the project but continue to represent a low proportion of den boxes when compared to results in the Central Interior of BC (Davis 2020). There are several potential reasons for the low detection rate and lack of reproductive use; however, a very low-density fisher population in the Site C area and a plentiful supply of potential den trees are the most likely reasons for these results. Despite the lack of reproductive use, information from this project along with future monitoring can provide important information on den box longevity for conservation efforts and fisher abundance may increase in the future making den boxes a viable alternative for reproductive female fishers.

I recommend leaving the structures installed to continue providing potential reproductive habitat for fishers, rest sites for marten, and habitat for species such as red and flying squirrels. Most of the den boxes are still in good condition and the longevity of the den boxes structures is of interest given the costs to construct and install. Conducting periodic monitoring of the structures to determine how long they remain functional would be important for evaluating their conservation value. Conducting these surveys at five-year intervals is likely to provide sufficient time for environmental processes to affect the den boxes. I recommend surveys of boxes be conducted after an additional five years (i.e.,2028), ten years (2033) and fifteen years (2038), at which point the oldest boxes will have been installed 10, 15 and 20 years previously. If these surveys were conducted shortly after the reproductive season (August), there would be the opportunity to observe fisher hair at the entrance if there was reproductive use. In general, den boxes that fishers used for reproduction in other studies had copious amounts of hair around the opening due to the repeated entries and exits by females and kits (L. Davis, personal observations). If fisher reproduction was suspected, a more intensive monitoring program could be developed to help determine the extent and duration of fisher use.

6.0 Acknowledgements

Funding for this study was provided by the Site C – Clean Energy Project to help mitigate the effects of reservoir development on the fisher population. This work would not have been possible without the contributions of Brian Paterson of Zonal Ecosystem and Wildlife Consultants Ltd who managed the field portions of the project and contributed to earlier reports. Monitoring of den boxes was aided by the hard work of Darcy Brown of the West Moberly First Nations and Ken Latreill of Mesa Environmental Services Ltd. The support of BC Hydro representatives Brock Simmons, Harry van Oort, and Brent Matsuda were also greatly appreciated.

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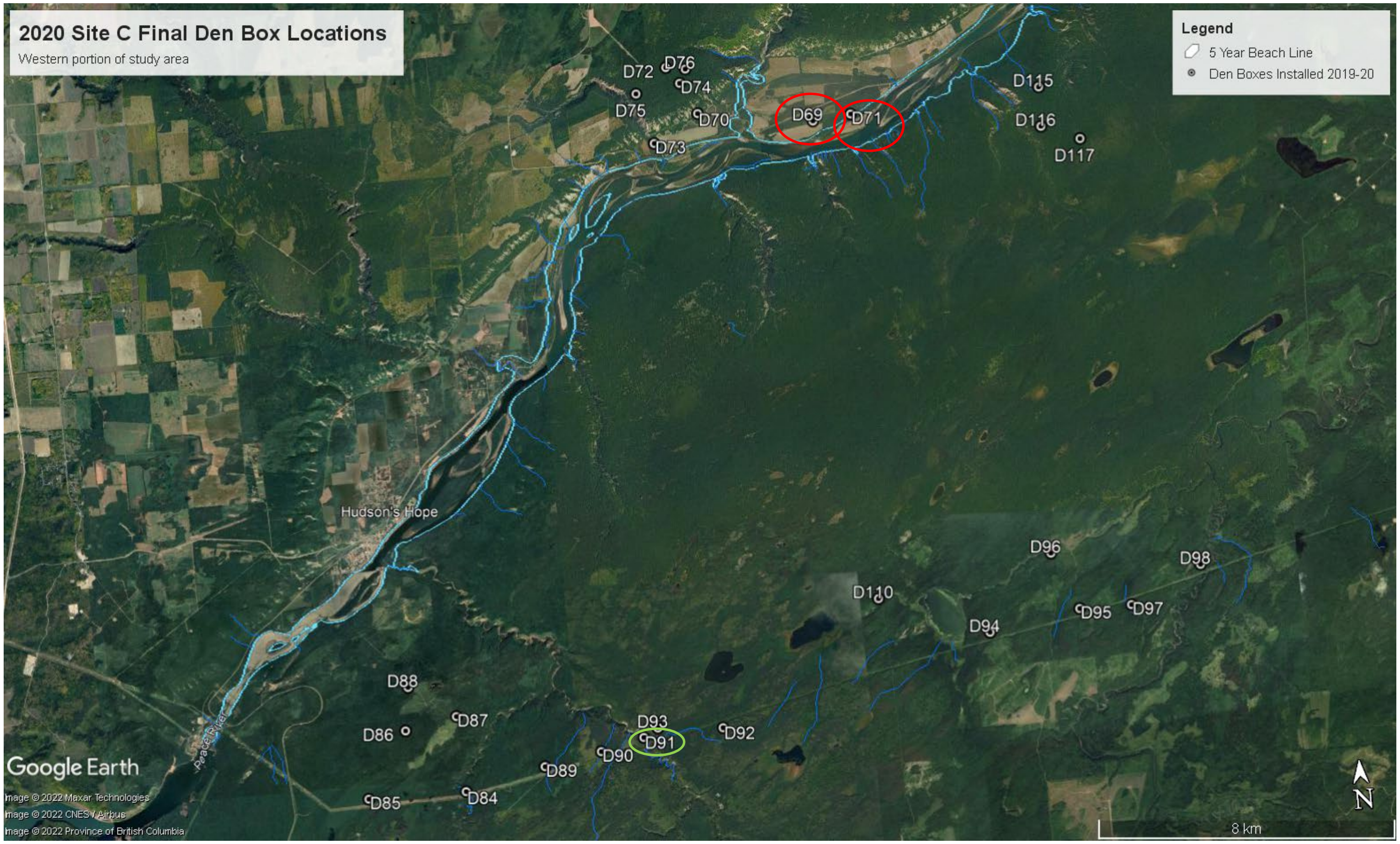
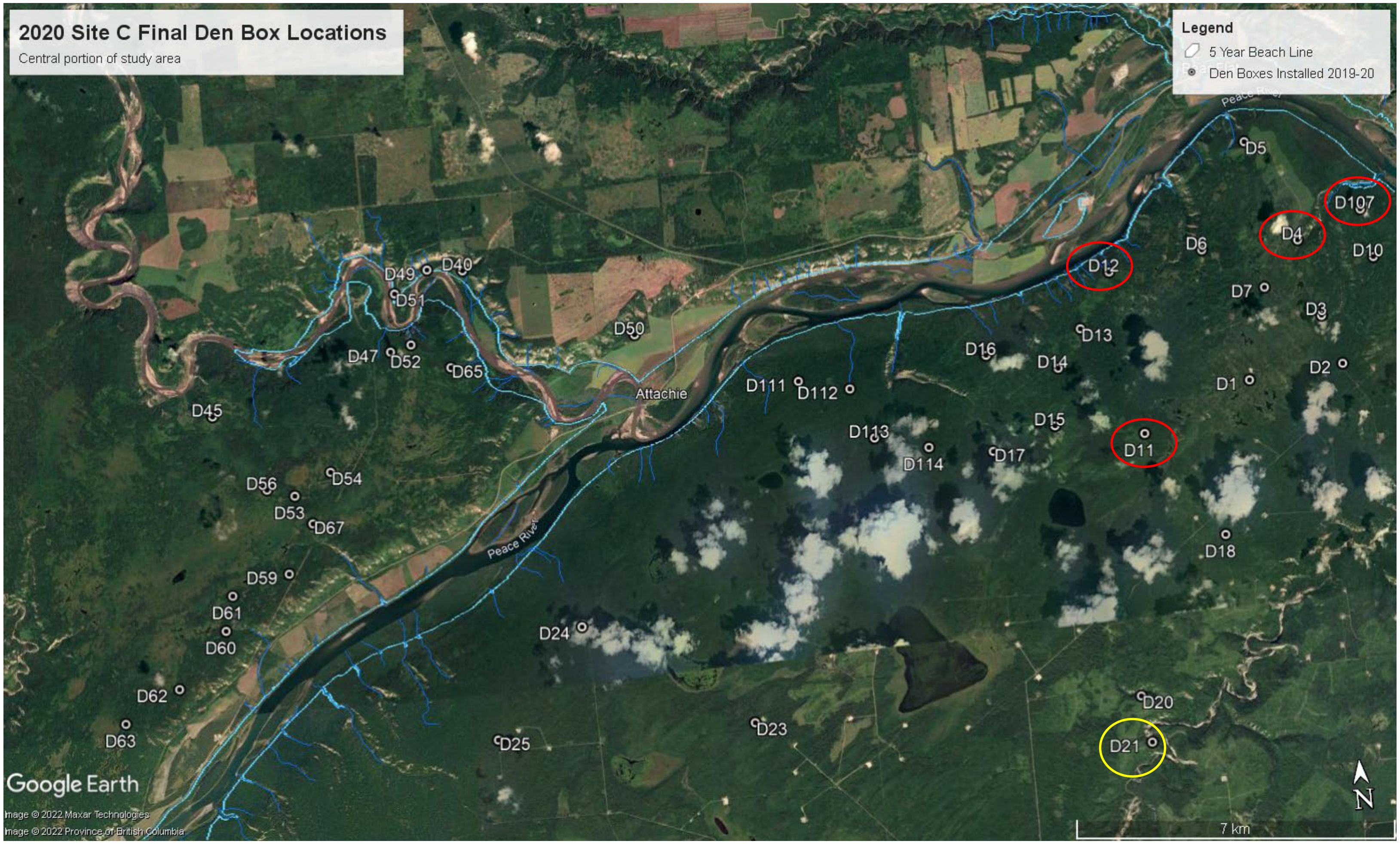
Appendix 1. Orthophoto of final den box locations at Site C



White icons with alphanumeric codes correspond to the den boxes deployed between November 2019 – March 2020 and yellow square icons with alphanumeric codes correspond to den boxes deployed in November 2018 in the eastern portion of the study area. Den boxes with fisher detections are circled with green (2020), yellow (2022), and red (2023). There were no detections in 2021.



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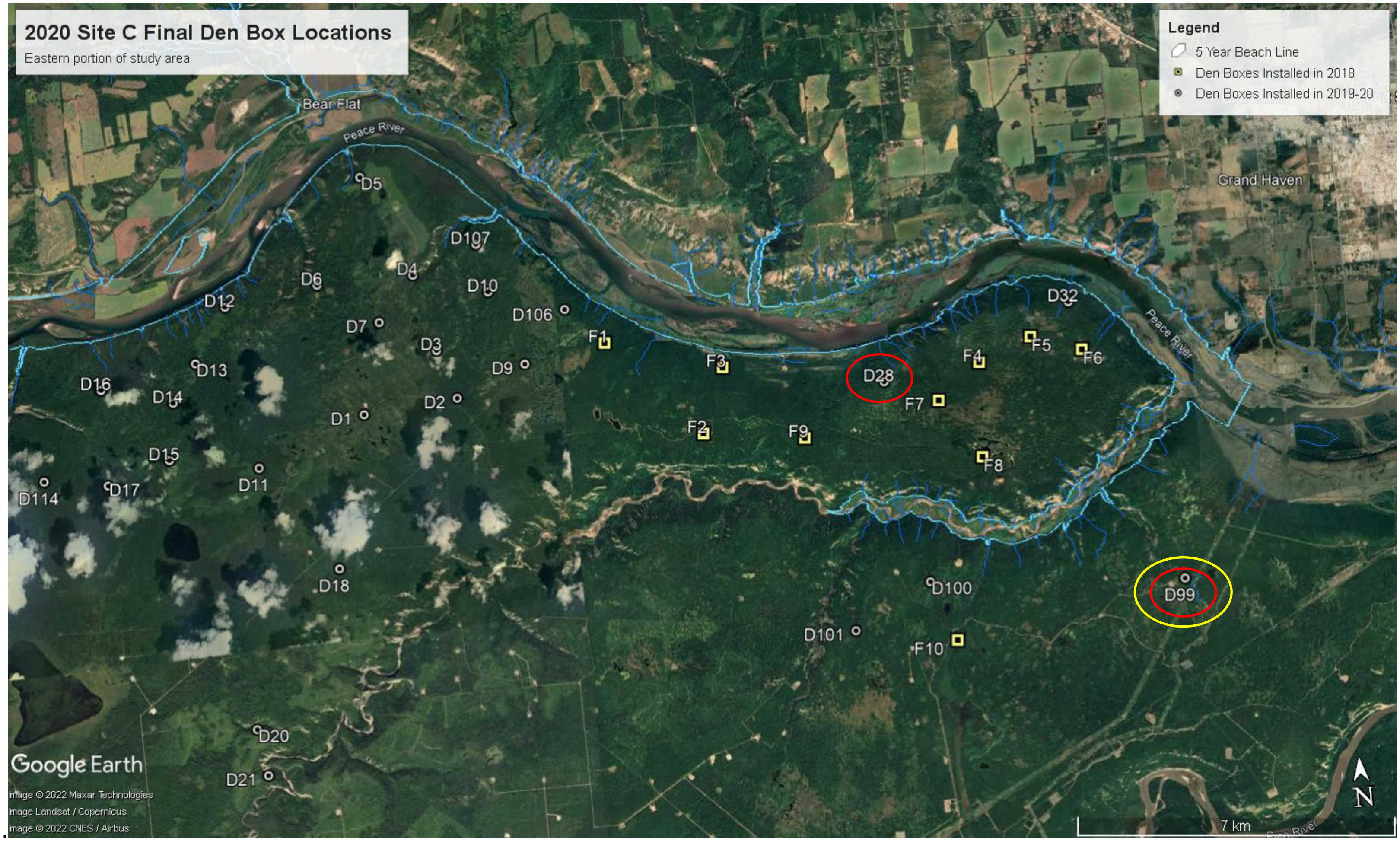

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Appendix 14. Bald Eagle Nest Surveys 2023 Annual Report

Ausenco

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Memorandum

Attention	Brent Matsuda, Senior Environmental Coordinator, Site C Clean Energy Project, BC Hydro
From:	Lorraine Andrusiak, M.Sc., R.P.Bio., Ausenco Sustainability Inc.
Subject:	Nest Surveys – Summary 2023
Date	March 1, 2024
Document Ref:	989619-05

1.0 Introduction

This memo summarizes the findings of Bald Eagle (*Haliaeetus leucocephalus*) nest surveys conducted in May and June 2023. The purpose of the surveys was to document the status of known and newly constructed Bald Eagle nests along the Peace River, at wetlands near the Site C transmission line, and at artificial (mitigation) nesting structures. The 2023 work is a continuation of the surveys that were completed in 2016 through 2022 (Hemmera 2016, 2018a, 2018b, 2019, 2021, 2022; Ausenco 2022) and during baseline studies for the Site C Clean Energy Project (Keystone 2009).

Bald Eagle nest surveys were conducted with two objectives:

1. Determine the status (active/not active) and productivity of known and newly constructed Bald Eagle nests in the study area, and
2. Provide the data to BC Hydro to inform Site C construction mitigation.

Data collected during these surveys provide information on the spatial distribution, timing and productivity of nests in the study area.

1.1 Background

Construction of the Site C reservoir has resulted in removal of Bald Eagle nest trees. The BC Ministry of Forests, Lands, and Natural Resource Operations issued Eagle Nest Permit FJ14-154018 on July 6, 2015 under the BC *Wildlife Act* allowing BC Hydro to remove Bald Eagle nests in the Peace Region in Management Units 7-31 through 7-35 (BC Hydro 2021). One of the permit conditions was installation of a minimum of 38 artificial nest platforms to replace the nests removed. Installation of artificial eagle nest platforms has been ongoing since 2019, for a total of 30 nest platforms available in 2023. The nest platforms are placed within 200 to 600 m of the future reservoir shoreline (BC Hydro 2021) and are therefore likely too far from water to be attractive sites for nesting prior to reservoir filling.

Bald Eagle nest monitoring has been carried out annually in the Site C footprint area since 2016 to collect data on eagle use of tree nests and use of artificial nest platforms as they are installed. Bald Eagle nestlings grow quickly in the first days and weeks after hatching, resulting in large size differences among siblings (Bortolotti 1986a). A third chick in a nest is at a disadvantage and will likely starve due to being out-competed by its larger siblings (Gerrard and Bortolotti 1988, as cited in Buehler 2021). In two-chick broods, both chicks generally survive (e.g., 95% of two chick broods in Saskatchewan were successful [n=37] [(Bortolotti 1986b)]). Therefore, when calculating nest productivity, if three chicks were observed in a nest during the final survey round, it was assumed that two chicks survived and fledged.

Second clutches are not observed in natural Bald Eagle populations (Buehler 2021), likely due to the long duration of breeding (Newton 2010). Exceptions are known when eggs or nestlings are artificially removed as part of captive breeding programs (Morrison and Walton 1980; Wood and Collopy 1993), or eggs are lost early in the season (Steenhof and Newton 2007). No second clutches have been observed in the study area to date.

2.0 Methods

Three rounds of nest surveys were conducted by helicopter on May 12 and 28, and June 19, 2023, with a two-person crew consisting of a crew lead and a technician, following methods outlined by the Resources Inventory Committee (RIC 2001). The study area is composed of the Peace River Valley from Hudson's Hope to the Alberta Border, as well as natural wetlands adjacent to the Site C transmission line right-of-way.

Previously identified nest locations from past aerial surveys (Ausenco 2022) were visited. In addition to known nests, a search was conducted simultaneously for new nests. Bald Eagle nests reported by other crews working for BC Hydro were also visited. Nests that were known to be destroyed since the previous year's surveys (e.g., the nest disintegrated, the host tree failed naturally, or the host tree was felled) were not visited in 2023, but searches were conducted in those areas for newly constructed nests. BC Hydro provided locations of platform nests, which were also visited.

The observations recorded at each known or new nest (or stick nests constructed by other species) were nest status ("active", "inactive", "not detected", "tree gone", "unknown"), bird species observed at each nest, and number of nestlings. Nests that were observed to have eggs or attending adults during the first survey but were empty on the subsequent surveys were categorized as 'active – failed'. Eagle nests that were used by other species were categorized as 'active-other' and were not included as active nests for the purposes of calculation of the proportion of active nests.

Status was determined by the presence of attending adults or evidence of nestlings. Productivity was estimated by counting the number of nestlings in each nest at the time of the last survey with the assumption that most nestlings reach fledging (Buehler 2021). Annual productivity was calculated as the sum of estimated productivity from active nests divided by the number of active nests. The following assumptions were used to determine nest status and productivity:

- Active eagle nests were those with evidence of adults attending the nest during any one of the field surveys:

- The number of chicks fledged (nest productivity) was determined as follows:
  - For nests that were **active** on the last survey: the number of chicks in a nest at the last observation, except nests with three chicks which were assumed to fledge two chicks (Gerrard and Bortolotti 1988, as cited in Buehler 2021);
  - For nests that were **inactive** on the last survey: the number of chicks last observed in a nest if the chicks had been assessed to be of fledging age.
- No eagles attempted second clutches.

As this is an interim report, only simple summary statistics (i.e., nests active, estimated fledged chicks per active nest) were calculated. Survey results were provided to BC Hydro in Excel (.csv) and spatial (.kml) format, including applicable comments and coordinates for each nest.

3.0 Survey Results

Surveyors conducted three visits at nearly all of the tree and platform nests but could only do the first and third surveys at one platform nest and three tree nests due to active forest fires burning during the second survey period. Of the three tree nests in the fire zone, one was known to fledge a single chick. The remaining two nests, both of which were active during the first visit, had no activity during the third visit.

Surveyors visited the locations of 37 tree nests, of which 33 were potentially usable (i.e. detected on surveys and still standing [available for use]) and 30 artificial nesting platforms in 2023 (**Appendix A**). No artificial nesting platforms were used by eagles. Of the 33 potential tree nests, 24 (73%) were used by Bald Eagles (i.e. eggs, incubating adult or chicks observed) and 9 were either inactive or were used by species other than eagles (**Table 1**). Twenty-eight chicks were observed and assumed fledged, with chick numbers ranging from one to two chicks per nest (Appendix B). The estimated fledging success in 2023 was 1.17 fledged chicks per active nest.

Table 1 Bald Eagle Nest Status and Productivity 2016 - 2023

Nest Status	2016	2017	2018	2019	2020*	2021	2022	2023
Tree Nests								
Active eagle use	NEI	34	28	29	25	25	19	24
Inactive (includes active non-eagle)	8	7	15	19	16	17	17	9
Percent Active	-	**83**	**65**	**60**	**61**	**60**	**53**	**73**
Not Detected/Tree Gone	-	18	4	6	11	15	0	4
Unknown	52	-	1	0	0	0	0	0
Total Nests Surveyed	**60**	**59**	**48**	**54**	**52**	**57**	**36**	**37**
Estimated productivity (total chicks)	**NEI**	**39**	**34**	**42**	**46**	**32**	**22**	**28**
Estimated young fledged per active nest (fledging success rate)	**NEI**	**1.15**	**1.21**	**1.45**	**1.84**	**1.28**	**1.16**	**1.17**

Nest Status	2016	2017	2018	2019	2020*	2021	2022	2023
Artificial Nesting Structures								
Active	-	-	-	0	0	0	0	0
Inactive	-	-	-	3	3	29	29	30
Total Structures Surveyed	-	-	-	**3**	**3**	**29**	**29**	**30**
Estimated productivity (total chicks)	-	-	-	**0**	**0**	**0**	**0**	**0**
Estimated young fledged per active nest (fledging success rate)	-	-	-	**0**	**0**	**0**	**0**	**0**

Note: NEI = not enough information
"-" indicates no data
* Estimates of productivity (fledged per active nest) in 2020 were based on only two surveys rather than three and some early active nests may have been missed. Therefore, active nests may be underestimated and, consequently, young fledged per active nest may be overestimated.

The nine inactive nests included one used by Canada Goose (*Branta canadensis*) and one used by Common Ravens (*Corvus corax*). No nesting activity was observed at the 30 artificial nesting platforms although some possibly new nest material was noted in one platform during the first survey.

Nest monitoring has been conducted since 2016 (**Figure 1**), with adequate data collected since 2017 to estimate productivity (**Table 1; Figure 2**). The average number of active nests from 2017 to 2023 was 26.3 ± 4.7 standard deviation (SD). The average annual total chicks from 2017 to 2023 was 34.7 ± 8.3 SD. The average number of young fledged per active nest from 2017 to 2023 was 1.32 ± 0.25 SD (**Table 1**).

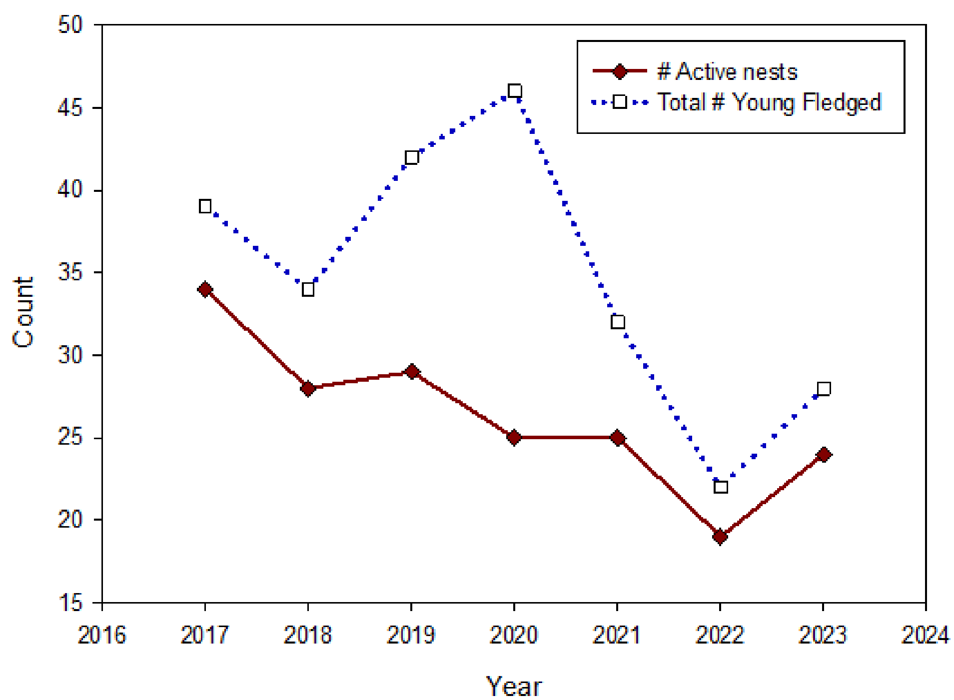

Figure 1 Number of Active Bald Eagle Nests and Total Number of Young Fledged Per Year From 2017 to 2023

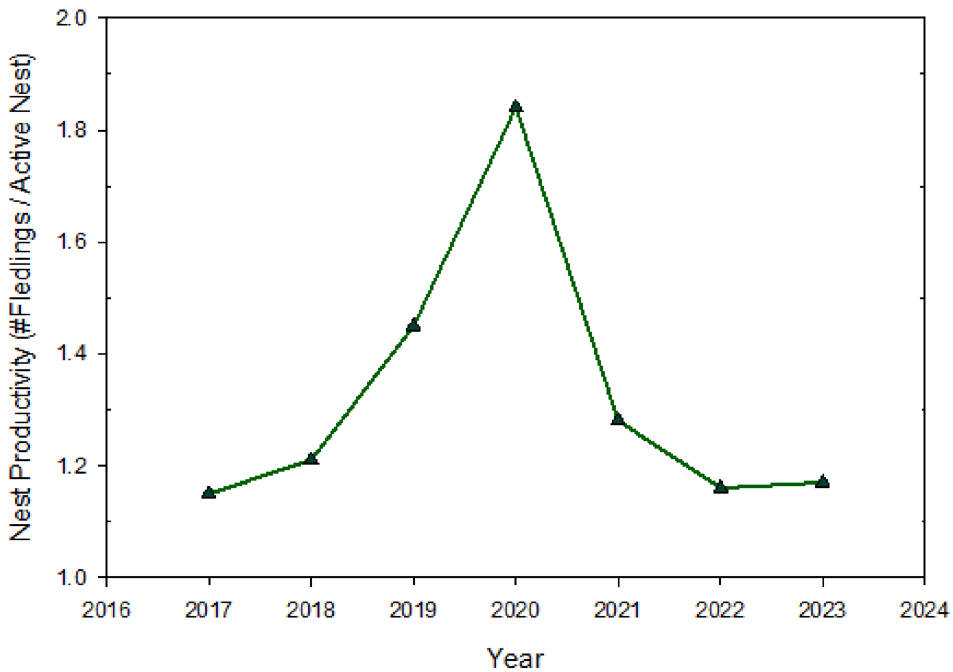

Figure 2 Bald Eagle Annual Nest Productivity From 2017 to 2023

4.0 Discussion

This is the seventh year of annual productivity monitoring of the Bald Eagles nesting in the study area (2017 to 2023). Data collected in 2023 indicate an increase in the total numbers of chicks fledged compared to 2022. The highest productivity observed was 46 in 2020, which declined by more than 50% (22 chicks) in 2022. 2020 was also the year with the greatest fledging success of 1.84 chicks per active nest compared to 1.17 fledged chicks per active nest in 2023. Studies conducted in 1995 and 1997 at the Williston Reservoir, approximately 188 km upstream of the Site C dam, averaged 0.78 fledged chicks per active nest, which is lower than observed in our study (Merkens et al. 1997; Booth et al. 1999).

The number of active nests was greatest in 2017 with 34 active nests observed, which dropped to a low in 2022 when only 19 active nests were observed. The 2023 data show an increase in active nests from 2022.

Productivity of raptors is influenced by many factors, including environmental conditions, disease and available nesting habitat. As discussed in the 2022 report, the relatively low eagle productivity in 2022 may have been due to weather as spring temperatures and high precipitation have been correlated with reduced chick production, active nests and fledge success (Bangerter et al. 2021; Gende et al. 1997). Progressive reservoir clearing prior to inundation has reduced the availability of suitable nesting habitat in the Peace River valley.

As reservoir filling is planned to occur in fall 2023, large areas of forest have been cleared, altering eagle nesting habitat. Once the reservoir is filled, landscape changes such as a reduction in the distance from water to nesting habitat will occur, and productivity and artificial nest use will be re-evaluated. Surveys using the methods described here have occurred annually through the construction phase of the Project and will continue through the first 10 years of operations, as per the commitments in the Site C Mitigation and Monitoring Program (BC Hydro 2021).

5.0 Closure

This work was performed in accordance with Contract BCO95055 between Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and BC Hydro (Client), dated 21 June 2016. This report has been prepared based on fieldwork conducted by Hemmera, for the sole benefit and use by BC Hydro. In performing this work, Hemmera has relied in good faith on information provided by others and has assumed that the information provided by those individuals is both complete and accurate. This work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time-sensitive and are considered valid only at the time the report was produced. The conclusions and recommendations contained in this report are based upon the applicable guidelines, regulations, and legislation existing at the time the report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

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Appendix A

Nest Survey Results 2023

Record #	Nest_ID	Latitude	Longitude	First Detected	2023 Activity	Species	Nest Substrate
1	22	56.13563	-120.640732	pre-2014	Active (other)	Canada Goose	Tree
2	29	56.107913	-120.099152	pre-2014	Active (Fledged)	Bald Eagle	Tree
3	38	56.105158	-120.441541	pre-2014	Active (Fledged)	Bald Eagle	Tree
4	100	56.157959	-120.751805	pre-2014	Active (Fledged)	Bald Eagle	Tree
5	104	56.194969	-120.800772	pre-2014	Active (Fledged)	Bald Eagle	Tree
6	146	56.005196	-121.959974	pre-2014	Active (Fledged)	Bald Eagle	Tree
7	203	55.997013	-121.721242	pre-2014	Active (Failed)	Bald Eagle	Tree
8	222	56.093503	-120.349667	pre-2014	Inactive	-	Tree
9	225	56.003474	-121.677346	pre-2014	Inactive	-	Tree
10	607	56.118299	-120.54547	2017	Inactive	-	Tree
11	608	56.147848	-120.708719	2017	Tree gone	-	Tree
12	610	56.057325	-121.115654	2017	Tree gone	-	Tree
13	611	56.002778	-121.679799	2017	Active (other)	Common Raven	Tree
14	802	56.195208	-120.847432	2019	Active (Fledged)	Bald Eagle	Tree
15	803	56.112141	-120.529482	2019	Active (failed)	Bald Eagle	Tree
16	804	56.138087	-120.019688	2019	Active (Fledged)	Bald Eagle	Tree
17	805	56.064382	-121.095033	2019	Inactive	-	Tree
18	806	56.136127	-120.642822	2019	Active (Fledged)	Bald Eagle	Tree
19	1001	56.190211	-120.890286	2021	Tree gone	-	Tree
20	1100	55.99477	-121.65667	2021	Inactive	-	Tree
21	1102	56.10305	-120.25499	2021	Active (Fledged)	Bald Eagle	Tree
22	1103	56.19153	-121.51116	2021	Inactive	-	Tree
23	1105	56.24904	-121.14629	2021	Active (Fledged)	Bald Eagle	Tree
24	1106	56.00555	-121.67447	2021	Active (Failed)	Bald Eagle	Tree
25	1110	56.22109	-121.059517	2021	Tree gone	-	Tree
26	2201	56.011502	-121.923083	2022	Active Unknown	-	Tree

Record #	Nest_ID	Latitude	Longitude	First Detected	2023 Activity	Species	Nest Substrate
27	2202	56.028036	-121.899608	2022	Active Unknown	-	Tree
28	2203	56.119679	-121.666751	2022	Inactive	--	Tree
29	2204	56.132945	-121.620312	2022	Active (Fledged)	Bald Eagle	Tree
30	2205	56.165529	-121.565091	2022	Active (Failed)	Bald Eagle	Tree
31	2206	56.177167	-121.522078	2022	Active (Fledged)	Bald Eagle	Tree
32	2207	56.225671	-121.3979	2022	Active (Fledged)	Bald Eagle	Tree
33	2208	56.140699	-120.7123	2022	Active (Failed)	Bald Eagle	Tree
34	2209	56.113856	-120.48277	2022	Active (Fledged)	Bald Eagle	Tree
35	2210	56.098417	-120.184053	2022	Active (Fledged)	Bald Eagle	Tree
36	2211	55.97833	-121.99086	2022	Active (Fledged)	Bald Eagle	Tree
37	2301	56.19058	-120.89107	2023	Active (Fledged)	Bald Eagle	Tree
38	Eagle_134_East	56.243279	-121.320574	2022	Inactive	-	Platform
39	Eagle_134_West	56.24284171	-121.325927	2021	Inactive	-	Platform
40	Eagle_14.1	56.22482582	-120.9380538	2021	Inactive	-	Platform
41	Eagle_142	56.24337297	-121.3944903	2021	Inactive	-	Platform
42	Eagle_144	56.2352197	-121.4039796	2021	Inactive	-	Platform
43	Eagle_147	56.23080701	-121.4137136	2021	Inactive	-	Platform
44	Eagle_151	56.23170841	-121.4351008	2021	Inactive	-	Platform
45	Eagle_153	56.22785045	-121.4505666	2021	Inactive	-	Platform
46	Eagle_153_East	56.22949139	-121.4424183	2021	Inactive	-	Platform
47	Eagle_167	56.2504824	-121.5058218	2021	Inactive	-	Platform
48	Eagle_182C	56.18959271	-121.5161017	2021	Inactive	-	Platform
49	Eagle_216B	56.18719662	-121.5246218	2021	Inactive	-	Platform
50	Eagle_217	56.18436136	-121.5340437	2021	Inactive	-	Platform
51	Eagle_246	56.11959613	-121.700627	2021	Inactive	-	Platform
52	Eagle_247 east	56.11782301	-121.7097745	2021	Inactive	-	Platform
53	Eagle_249_East	56.1180545	-121.7208007	2021	Inactive	-	Platform

Record #	Nest_ID	Latitude	Longitude	First Detected	2023 Activity	Species	Nest Substrate
54	Eagle_254_West	56.12483942	-121.7551792	2021	Inactive	-	Platform
55	Eagle_257N	56.12191123	-121.7687378	2021	Inactive	-	Platform
56	Eagle_258_East	56.12062749	-121.7769985	2021	Inactive	-	Platform
57	Eagle_326	56.0707243	-121.8540666	2021	Inactive	-	Platform
58	Eagle_41.1A	56.21323424	-121.0643504	2021	Inactive	-	Platform
59	Eagle_41.1B	56.2141132	-121.075756	2021	Inactive	-	Platform
60	Eagle_48	56.23015272	-121.0930696	2021	Inactive	-	Platform
61	Eagle_49.1B	56.21772486	-121.1053797	2021	Inactive	-	Platform
62	Eagle_49.2B	56.21559669	-121.0943731	2021	Inactive	-	Platform
63	Eagle_75	56.2545448	-121.1846652	2021	Inactive	-	Platform
64	Eagle_75.1	56.25008933	-121.1768376	2021	Inactive	-	Platform
65	p32	56.240476	-121.129658	2018	Inactive	-	Platform
66	p39	56.234984	-120.955227	2018	Inactive	-	Platform
67	p47	56.232966	-121.100321	2018	Inactive	-	Platform

Appendix B

Active Bald Eagle Nests and Assumed Productivity 2023

Nest ID	Comments May 12, 2023	Comments May 28, 2023	Comments June 19, 2023	Total Chicks Fledged
29	Adult on nest with 2 chicks	2 chicks with dark grey feathers	2 mottled chicks with adult on nest	2
38	2 grey chicks and adult on nest	2 grey chicks with adult perched above in tree	2 mottled chicks	2
100	Adult and one grey feather chick.	2 grey chicks	1 mottled chick in nest	1
104	Adult and single, small, downy chick	Adult and one grey chick in nest	2 grey feathered chicks and adult in nest	2
146	Adult sitting test on nest. Likely incubating.	Fire Zone - could not enter	2 adults in nest with single dark-feathered chick	1
203	Adult on nest with two eggs. Adult left nest on approach	No activity	Inactive	0
802	Adult with one grey chick	2 grey chicks	2 dark feathered chicks in nest	2
803	Adult sitting tight. May be incubating. Another adult flew by.	Nest empty but adult within 50 m	Nest is empty	0
804	2 adults on nest with 1 grey chick.	Adult and 1 grey chick on nest	2 dark chicks in nest adult flying around	2
806	2 grey chicks and adult on nest	2 chicks and adult on nest	2 chicks on nest with adult feeding	2
1102	1 grey chick for sure maybe 2	2 grey chicks	2 mottled chicks	2
1105	Adult and two grey chicks on nest	2 grey chicks	1 black feathered chick with adult in nest	1
1106	Adult sitting on nest. Likely incubating. Didn't budge.	Empty nest	Empty good condition. Adult around Lake margin.	0
2201	Adult with single grey feathered chick.	Fire Zone - could not enter	Adult seen flying nearby. No chicks in nest. Fledge?	0
2202	Active. Adult incubating. Looks like eggs under her - can just make out in photo	Fire Zone - could not enter	Inactive. Nothing in nest. Had to avoid last time due to fire.	0
2204	Two grey downy chicks plus adult in nest.	2 black feathered chicks	2 large black-feathered chicks	2
2205	Single egg in nest. No adults around. Maybe abandoned?	Empty nest	Good condition	0
2206	2 chicks starting to get flight feathers. Adult perched nearby.	2 grey-feathered chicks with adult in nest.	Two large black-feathered chicks ready to fledge	2
2207	Adult and two grey feathered chick on nest. Another adult nearby.	2 grey feathered chicks	1 black-feathered chick	1
2208	No new material	Three eggs in nest no adult	Nest ok but filled with broken cottonwood and aspen branches	0

Nest ID	Comments May 12, 2023	Comments May 28, 2023	Comments June 19, 2023	Total Chicks Fledged
2209	2 chicks on nest. No adult observed.	2 large black chicks	1 large chick	1
2210	2 grey chicks in nest. Adult perched nearby but not on nest	2 black feathered chicks	2 mottled chicks	2
2211	Adult on nest with two grey chicks	2 black feathered chicks	2 black-feathered chicks.	2
2301	Adult with one grey chick. Very close to previous nest 1001 which apparently BCH cut down.	One mottled chick with adult in nest	Black feathered chick and adult on nest	1
Total Chicks				**28**