SITE C CLEAN ENERGY PROJECT

VOLUME 1 APPENDIX J

ALTERNATIVES MEANS OF CARRYING OUT THE PROJECT

SUPPORTING DOCUMENTATION

PART 1 – SITE C NORTH AND SOUTH BANK CAMPS WATER & SEWER FEASIBILITY STUDY

Revision 1 – July 19, 2013

BC hydro
FOR GENERATIONS

Report

BC hydro

Site C North and South Bank Camps
Water & Sewer Feasibility Study
FINAL - CONFIDENTIAL

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Site C Camps
Water & Sewer
Feasibility Study

Report

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EXECUTIVE SUMMARY

As requested by BC Hydro, Urban Systems Ltd. has completed a review of the water and wastewater servicing options for the proposed North Bank Camp and water servicing options only for the South Bank Camp for the Site C dam project. These water and wastewater systems are intended to provide services to the camps during the construction phase of Site C, as well as during the long term operations of the dam office (north side only).

The purpose of this study was to evaluate the feasibility and Class 'D' construction cost estimates for the following servicing options for the proposed North and South Bank Camps:

- North Bank Camp Potable Water Servicing Options
  - Construction of a standalone potable water system (groundwater and surface water evaluated); and
  - Connection to the City of Fort St. John's potable water system.

- South Bank Camp Potable Water Servicing Options
  - Construction of a standalone potable water system (groundwater and surface water evaluated.

- North Bank Camp Sanitary Sewer Integrated Servicing Options
  - Connect to the Peace River Regional District's Charlie Lake Lagoons, and
  - Connect to the City of Fort St. John's sanitary sewer system.

A summary of the Class 'D' cost estimates for each servicing option as well as some key considerations that should be taken into account as part of the selection of the preferred servicing options is as follows:

1) Standalone Potable Water Supply Systems
   a) North Bank Camp - Surface Water Source = $3.3 million
   b) North Bank Camp - Groundwater Source = $3.0 million
   c) South Bank Camp - Surface Water Source = $5.1 million
   d) South Bank Camp - Groundwater Source = $5.3 million

Both surface water and groundwater appear to be suitable sources for a standalone water supply system for both camps; however, additional analysis is required to confirm a suitable location for each source. Also, as part of the design phase, the supply and treatment systems should be designed to accommodate the anticipated fluctuations in design flow which should be reviewed in concert with the overall camp design. This may be achieved a number of different ways such as having multiple

pumping/treatment trains in parallel or potentially retrofitting the processes to accommodate large reductions in water demand post construction at the North Bank Camp.

2) North Bank Camp - Connection to City's potable water system = $3.5 million

Connecting to the City's water system may have reduced operation and maintenance requirements, however, the City typically does not service outside their municipal boundaries and therefore an agreement must be developed with the City prior to pursuing this option any further. Also, although the distribution system can accommodate the added demand on the City's water system, the City's water supply and treatment infrastructure is nearing the limits of its capacity and therefore it is recommended that the implications of connecting to the City's water system, specifically related to upgrades to major water infrastructure, are further defined. Additional design considerations should include the evaluation of the long term demands at the North Bank Camp to ensure degraded water quality associated with stagnation in the long water supply line is not an issue.

3) North Bank Camp - Sanitary Sewer Integrated Servicing Options
   a) Connection to the Charlie Lake Sewer Lagoons = $4.1 million
   b) Connection to the City of Fort St. John's wastewater system = $3.5 million

Connecting to the Charlie Lake Sewer Lagoons will require the installation of solids handling processes prior to it being pumped up and treated at the Charlie Lake Lagoons. Connection to the CFSJ's sanitary system will require installation of multiple lift stations to convey the wastewater flows. Both options identified will require ongoing operation and maintenance. From a treatment capacity perspective, the City's system is better suited to accommodate additional sanitary flows while the Charlie Lake Sewer System is very close to capacity and would require significant upgrades. It is recommended that both sanitary integration options are discussed in greater detail with the City of Fort St. John and the Peace River Regional District in order to get a better understanding of additional capital upgrades that may be required to connect to their systems. Also, if either sanitary sewer integration option is pursued, it is recommended that additional design considerations are taken into consideration to ensure the reduced flows and long forcemain lengths do not result in treatment and operational issues either from a mechanical pumping perspective or a treatment perspective for the community sewer systems.

It may also be beneficial to explore future partnerships with the City and the Peace River Regional District to ensure upgrades will be mutually beneficial to both the local

residents and BC Hydro. Some mutually beneficial topics for discussion identified in this study include:

- Sizing upgrades to the Charlie Lake lagoons to meet the ultimate design capacity for the neighbouring Grandhaven and Clairmont subdivisions and the North Bank Camp;
- Aligning any upgrades to the Charlie Lake outfall which may need to be relocated as a result of the dam construction so that it aligns with potential standalone wastewater processes for the North Bank Camp; and
- Creating a new wastewater treatment system that may accommodate the long term needs of the PRRD (Grandhaven and Clairmont subdivision) and the North Bank Camp.

This report focused on the technically feasible options available for providing water and sewer to the camps, while keeping in mind the planning of future water and sewer infrastructure in the region. The City has expressed that service will not be provided to the North Bank Camp without a City boundary expansion. The integration options presented in this report provide a technically feasible option for servicing the camp that could also (depending on ultimate pipe sizing) provide benefit to properties adjacent to the camp supply lines. If a boundary expansion occurred and the City wanted the newly incorporated properties between the camp and the current city boundary serviced, further review of the infrastructure would be required. A future service area and level of service would need to be defined by the City at that time. This detail was beyond the scope of this feasibility study.

The findings of this study are meant to provide BC Hydro with additional insight into the implications of the various servicing options reviewed in this study for the North and South Bank Camps. Prior to the selection of the preferred servicing options, it is recommended that some of the assumptions made in this study are further defined such as the potential flow variation, the layout of the camp, as well as the Peace River Regional District and the City's perspective related to the various integration options.

As outlined in the report background, additional servicing options exist that were not explored as part of this report. It is recommended that further analysis is undertaken to review other possible servicing options such as hauling water and/or sewer to and from site or standalone sewer system options. It is also recommended that the life cycle costs of the various options are reviewed as part of the servicing selection process to ensure BC Hydro contains all the information necessary to make an informed decision.

1.0 BACKGROUND

The purpose of this study is to review the feasibility and costs associated with providing the proposed North Bank Camp with water and sewer servicing and the proposed South Bank Camp with water servicing alone. The study was also intended to review long term service infrastructure planning and interests in the area and to identify opportunities to integrate infrastructure upgrades to meet the long term needs of the neighbouring communities, as well as those of BC Hydro for the Site C work camps.

Urban System Ltd. (USL) was approached by BC Hydro to undertake this study as USL has been working with the communities throughout the Peace Region for over 20 years and has an intimate understanding of the existing infrastructure in the area, as well as the challenges with providing potable water and wastewater system in the vicinity of the proposed Site C Dam.

In response to the request from BC Hydro to undertake this study, USL submitted a proposal on November 28, 2011 to BC Hydro outlining a comprehensive feasibility study to review the following:

- North Bank Camp Sanitary Sewer Servicing Options
    - Standalone sanitary sewer system;
    - Hauled sanitary sewer options;
    - Connection to the Peace River Regional District's Charlie Lake Community Sewer System; and
    - Connection to the City of Fort St. John's sanitary sewer system.

- North Bank Camp Potable Water Servicing Options
    - Standalone water system;
    - Hauled water options; and
    - Connection to the City of Fort St. John's water system.

In consultation with BC Hydro, USL reduced the scope of the study. The scope of the revised work program submitted to BC Hydro on December 21, 2011 (Appendix A) included the following tasks:

- North Bank Camp Sanitary Sewer Servicing Options
    - One option, including a Class D cost estimate to connect to the Peace River Regional District's Charlie Lake Community Sewer System; and
    - One option, including a Class D construction cost estimate to connect to the City of Fort St. John's sanitary sewer system.

- North Bank Camp Potable Water Servicing Options
    - Feasibility of standalone water system, including a Class D construction cost estimate; and
    - Connection to the City of Fort St. John's water system.

- South Bank Camp Potable Water Servicing Options
    - Feasibility of a standalone water system, including a Class D construction cost estimate.

The findings of this study are meant to provide additional insight into the various servicing options available to BC Hydro to service the North and South Bank Camps, as well as outline the capital costs associated with pursuing each option. Additional analysis is recommended to further define the life cycle costs of the various servicing options.

2.0 WATER SERVICING

As outlined in the work program included in Appendix A, an analysis of the potable water servicing options has been prepared. There are three main options to service the North and South Bank Camps with potable water. These include using a standalone system, connecting to the CFSJ's water system or hauling water to the camps with bulk water trucks. As outlined in Section 1.0, the scope of this study reviews the following:

1) North Bank Camp – Standalone water system and connecting to CFSJ's water system
2) South Bank Camp – Standalone water system only

In concert with the information presented in this study for water servicing, it is recommended that additional consideration is put towards the costs of hauling water to site prior to selecting the preferred water servicing option. For example, if either camp only experience peak water demands during isolated time frames, rather than designing a water supply system to meet the peak demand period, it may be economically advantageous to design the system to meet a lower water demand that better reflects the demands of the camp and supplement the peak flow conditions with water that is hauled to site.

2.1 Potable Water Quality Objectives

It is recommended that the water supply systems for the proposed work camps are designed to meet the BC Drinking Water Protection Regulation which governs systems that provide drinking water to more than one residence. This legislation requires that water suppliers provide "safe drinking water". The Northern Health Authority (NHA) is responsible for implementing this legislation in the Peace Region. The treatment objectives from NHA are included in Appendix B. These objectives require that all water suppliers meet or exceed the following criteria:

- 4 log (99.99%) reduction of viruses;
- 3 log (99.9%) reduction of Giardia and Cryptosporidium;
- 2 or more disinfection/treatment barriers for all surface water systems;
- less than 1 NTU of turbidity, with a target of 0.1 NTU; and
- 0 total and fecal coliforms and E.Coli.

The water quality should also adhere to the guidelines for Canadian Drinking Water Quality, which are included in Appendix C.

Treatment objectives usually also consider:

- Other jurisdictions (Canada and U.S.);
- Current requirements of the NHA and other Health Authorities in BC;
- Good engineering practice.

2.2 Camp Water Demands

The water demands for the two work camps provided by BC Hydro are based on the US Army Corps of Engineers – Engineering and Design Water Supply, General Considerations (April 1984). The design flows for the camps provided by BC Hydro are summarized in Table 2.1. The material provided by BC Hydro that form the basis of the design flows is included in Appendix D.

Table 2.1 – Camp Water Demands

	North Bank Camp		South Bank Camp	
Peak Population	500 people		1,200 people	
Water Required for Workers	425.25 m^3/day		1,020.6 m^3/day	
Fire Fighting Requirement	227.1 m^3/day		227.1 m^3/day	
Total Water Required Per Day	538.8 m^3/day	6.2 L/s	1,134 m^3/day	13.1 L/s
Peak Demand	1,347 m^3/day	15.59 L/s	2,835 m^3/day	32.82 L/s

It is recommended that the demands for the work camps are reviewed in greater detail as part of the design phase and take into consideration other possible water uses that may be encountered at the work camps. Based on discussions with other camp designers, it was determined that additional water uses were added to their camp water system as time passed, which was not considered as part of the original water supply systems. Some examples include using water for dust control, car wash stations, and bulk water truck filling.

2.3 Standalone Water System Considerations

The standalone system will utilize either groundwater or the Peace River (surface water) as the water source with the necessary conveyance and treatment processes in place to meet the final water quality requirements for potable water. The standalone system will also need to meet regulatory requirements from the Ministry of Environment (MoE), the Department of Fisheries and Oceans (DFO), and the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) and receive the necessary approvals from NHA as discussed in this study.

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SITE C CAMPS
WATER AND SEWER FEASIBILITY STUDY

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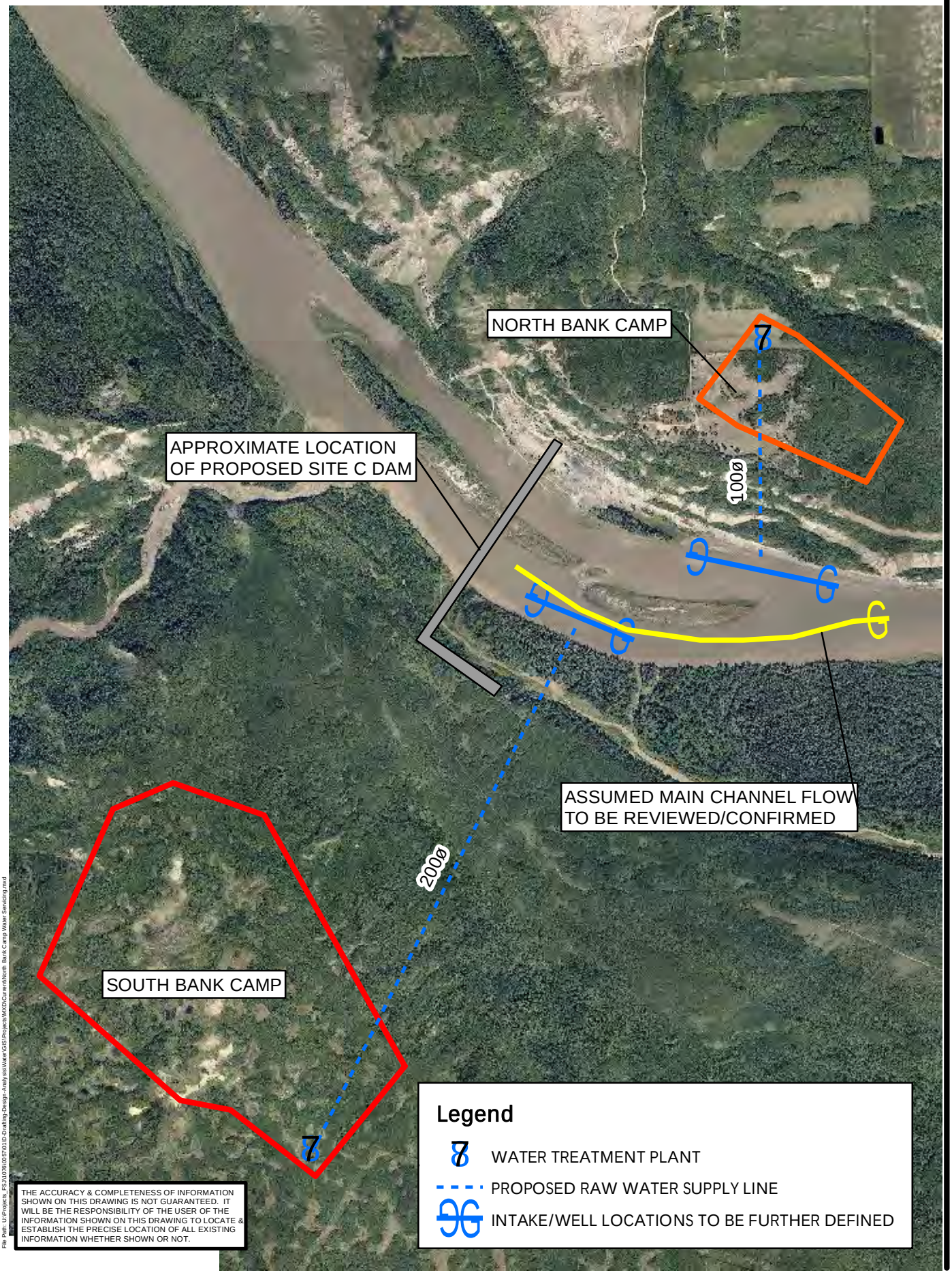

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STAND ALONE WATER SUPPLY OPTIONS

FIGURE
2.1

Based on the information provided, Figure 2.1 outlines the assumed water treatment plant, raw water supply alignment and intake locations which were used as part of our analysis. These locations must be reviewed in greater detail as part of the design phase and should consider the overall water system operation as well as site specific limitations such as bank stability, access routes and exposure to construction related hazards that may compromise the water supply system.

2.3.1 Source Options (Groundwater vs. Surface Water)

Both surface and groundwater appear to be suitable options for a water source for the proposed camps. These observations are based on the CFSJ's experience with their groundwater source as well as the water quality data collected by Golder Associates referenced in Appendix E. Some areas have been identified as having undesirable water quality parameters and should be reviewed in greater detail as part of the review of the source options.

Based on the CFSJ's experience in developing their wells, the most productive aquifers are located within the river valley. It is possible that a productive aquifer may be located closer to the camp sites; however, it is more likely that a suitable well will be located lower down within the river valley. A groundwater specialist should be consulted if groundwater is considered further as a source for the standalone water system. The main advantage to pursuing a groundwater source option is that currently there is no permitting and approval process (this is expected to change in the next couple of years under the Water Act Modernization process). Furthermore, groundwater is not as susceptible to contamination and seasonal variation, and therefore the water quality will likely be more consistent. However, the risks associated with developing wells include the potential that a productive well with a suitable water quality may not be found, or that multiple wells may need to be developed before a suitable well can be located, which will be very costly.

For a surface water source, the intake should draw water from the main channel flow, also known as the thalweg. Based on limited site information and the aerial photo, it appears as though the thalweg is closer to the south bank than to the north bank in the vicinity of the camps. For this reason, it is likely that the south bank intake will prove to be less costly compared to the north bank intake. In order to get a better understanding of the intake requirements and to identify the preferred intake location, a more detailed review of the river profile will be necessary. Since there is much water quality data available for the Peace River, the main benefit to pursuing a surface water source is the ability to design to a known water quality. Furthermore, the water storage provided by Williston Lake and Dinosaur Lake provides additional certainty that sufficient flow will consistently be available. The main disadvantages to pursuing a surface water source are the

potential for a lengthy approval process, which can take up to 2 years to process and involves multiple entities (MFLNRO, DFO, Navigable Water Act), and the risk of upstream operations (dam construction, oil and gas operations, etc.) and seasonal fluctuations which can compromise the water quality of the surface water source.

A Provincial Environmental Assessment will not be triggered for either a groundwater or surface water source if a standalone system is pursued. The triggers for these assessments are 10,000,000 m^3/year for a surface water source and 75 L/s for a groundwater source.

For the purposes of this study it is assumed that both an intake and a productive groundwater well would be available in the vicinity of the locations shown on Figure 2.1. Additional analysis is required to determine the preferred source option for both camps and should also look at potentially drawing water from upstream of the dam which could potentially substantially reduce the pumping requirements.

2.3.2 Pumping Requirements

The pumping requirements to convey flows to the camps depend on the intake/groundwater location, raw water supply line alignment and water treatment plant location. It is recommended that the pumps at the source (groundwater or surface water) are sized to pump water up to the treatment plant. Depending on land availability and the distribution system design, it is recommended that the treatment plant is located at an elevation that will allow treated water to flow by gravity to camp storage reservoirs which will avoid additional pumping requirements. A visual representation of the elevation changes for the two water supply systems is represented in Figure 2.2.

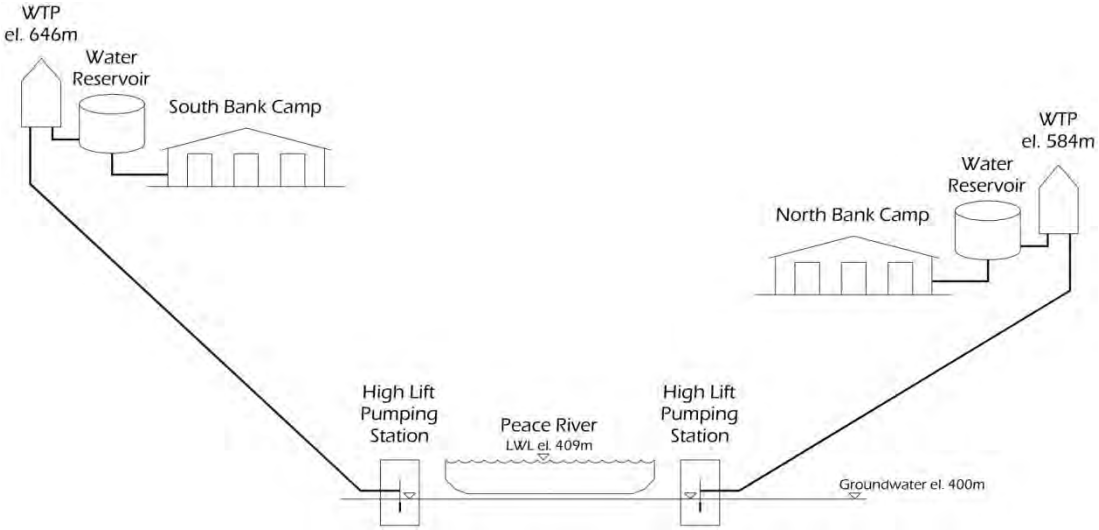

Figure 2.2 – Line diagram of the elevation changes in the standalone water supply systems.

The location of the water treatment plant, intake/groundwater location, raw water supply line alignment and their associated elevations are based on limited information and were only developed to provide an overview of the potential pumping requirements. The pumping requirements should be reviewed in detail and confirmed as part of the design phase of this project. Appendix F provides a summary of the pumping assumptions used for this study.

2.3.3 Water Treatment Requirements

Due to the proximity of the groundwater to the Peace River, it is assumed that the groundwater source will be considered GUDI (Groundwater Under the Direct Influence of surface water). Therefore, both source options will require similar treatment processes.

Based on the water quality data, the treatment processes required to meet the water quality requirements for both the surface water source and groundwater water source include chemical pre-treatment, filtration, UV disinfection, and chlorination as shown in Figure 2.3.

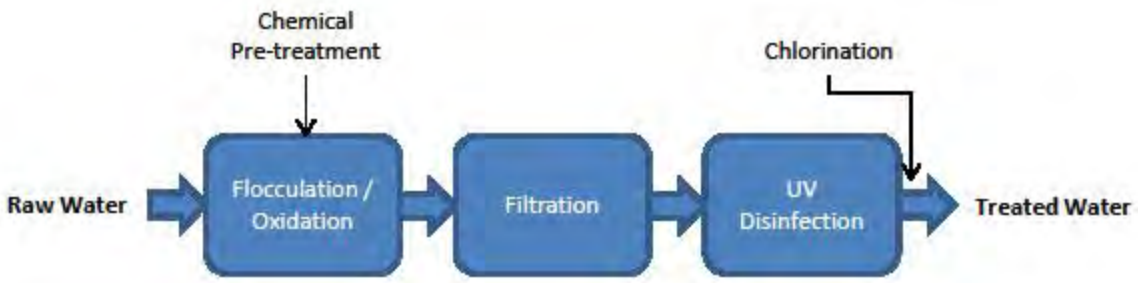

Figure 2.3 – Required Treatment Process

An overview of the intent of each treatment process component is outlined below.

1) <u>Chemical Pre-Treatment</u>

By using the surface water source (Peace River), coagulation will likely be required to aid in the removal of fine particles to meet the final water quality requirements. This process will likely also require a suitable downstream mixer and contact chamber to allow for flocculation. The flocculation process provides suitable contact time and mixing for the finer particles to bind to the coagulant to form larger particles, called floc, which can then be removed during filtration. There are a number of coagulant products and flocculation systems that may be used. It is recommended that jar testing be undertaken to select the appropriate coagulant and flocculation system specific to the water chemistry of the water source.

If the groundwater source is used, an oxidant will be required to precipitate out the dissolved iron and manganese, which may then be removed during filtration. Although iron and manganese are not regulated, most communities treat for these parameters to meet aesthetic objectives. The aesthetic objectives are meant to improve taste, eliminate staining of laundry, showers and toilets, and reduce the accumulation of iron and manganese precipitate from building up within the distribution system of a chlorinated water system. Chlorine, ozone, and permanganate are the most commonly used oxidants to precipitate out iron and manganese for municipal applications.

For the purposes of this study, it is assumed that the coagulant and/or oxidant will be added to the influent line upstream of an inline mixer, followed by flocculation tanks (for the surface water source only) to provide sufficient mixing and contact time upstream of the filtration process. The actual pretreatment requirements will depend on the water quality and the downstream treatment process and should be reviewed in detail as part of the design phase of this project.

It should be noted that flocculation tanks may not be required if it is determined that the final water quality objectives may be achieved without coagulation. This will ultimately be dictated based on the water quality and filtration process selected.

2) Filtration

Filtration is required to meet the final water quality for both surface water and groundwater under the direct influence of surface water (GUDI). In the event that a groundwater source is identified not to be GUDI, the filtration process may not be required to meet the regulatory requirements; however, due to the complexity of proving that groundwater is not GUDI and the likelihood of the iron and manganese in the groundwater being treated, it is recommended that a filtration process is included as part of treatment. Therefore, for the purposes of this study, we assume that filtration is required for both surface and groundwater sources.

There are a number of filtration processes available that should be reviewed as part of the design phase of this project. The selection of the appropriate filtration process should consider the water quality, the upstream processes and the skill set of the operator that will be operating the system. Media filtration and membrane filtration are two common types of filtration processes that should be reviewed as part of the filtration process selection. Generally speaking, media filtration is a much simpler mechanical process with less instrumentation and controls when compared to a membrane system; however, operating a media filtration process will require a better understanding of water quality to ensure a suitable upstream coagulant dosing and will also require a larger building footprint. Membrane

filtration is a more complex mechanical and instrumentation/control process and also has a higher capital cost when compared to media filtration; however, it requires a much smaller footprint and is very reliable in achieving the final water quality requirement. This is just an example of some of the considerations that should be reviewed in the selection of the appropriate filtration process. The selection of the appropriate filtration process is outside the scope of this study and should be reviewed in greater detail as part of the design phase. For the purposes of this feasibility study, membrane filtration is used for costing purposes.

3) UV Disinfection

UV disinfection is a very effective primary disinfection process for inactivating both Giardia cysts and Cryptosporidium oocysts and to control E. Coli and Coliforms for surface and GUDI water supplied treatment processes. The UV unit should be sized to provide a dose of 40 mJ/cm^2 during the design phase of this project.

UV disinfection is not required for groundwater that is not GUDI as Giardia, Cryptosporidium, E. Coli and Coliforms typically are not present in this type of groundwater. However, it is difficult to determine whether or not a groundwater source is GUDI, and therefore, for the purposes of this study, we assume that UV disinfection will be required.

It should be noted that filtration can be effective in removing Giardia, Cryptosporidium, E. Coli and Coliforms, but is significantly dependent on the type of filtration process. Chlorine may also be used to inactivate Giardia and also control E. Coli and Coliforms. This should be taken into consideration as part of the treatment process selection during the design phase of this project.

4) Chlorination System

Chlorination is a very effective primary and secondary disinfection process and is necessary to achieve the required inactivation of viruses. The chlorination system should be sized to ensure a minimum chlorine residual of 0.2 mg/L is maintained within the distribution system as an added measure to reduce the risk of bacteria and/or virus reactivation within the storage or distribution system that cause health issues. Furthermore, sufficient contact time should be included downstream of the chlorination injection point to ensure a thorough disinfection of the water prior to the first point of use. This is outside the scope of this study but should be reviewed as part of the camp reservoir and water distribution system design.

The most common methods of chlorination for potable water systems are bulk sodium hypochlorite and on-site sodium hypochlorite generation. Both systems inject a sodium hypochlorite solution into water. The only difference is that one

option uses concentrated sodium hypochlorite hauled to site while the other uses catalytic cells to generate sodium hypochlorite on-site using salt and water. Although there are advantages with using on-site sodium hypochlorite generation in terms of reduced safety requirements and reduced operating costs, the added capital cost generally has a payback period of over 7 years for communities over 3,000 people. Since these camps are going to be in operation for less than 7 years and low flows will be treated, it is recommended that bulk sodium hypochlorite is used to fulfill the chlorination needs for the camps.

5) Backwash Water

As part of every treatment process, there is a certain amount of water that is wasted. For the proposed filtration process it is common to see backwash water wasted of up to 10% of the treated water. Generally this water is either sent to backwash ponds or septic tanks, or the backwash water can be sent to a wastewater system. In the event the backwash water is sent to backwash ponds or septic tanks, these systems are designed to settle out the solids and then the water is discharged into the environment such as a large body of water (ex. Peace River) or into an infiltration gallery. For the purposes of this study, since we are considering the cost implication of a standalone system, we have assumed that the backwash water will be sent to solids settlement chambers and then the liquid will be discharged into an infiltration gallery to percolate into the ground.

It should be noted that the solids would accumulate in the solids settlement chambers and would need to be removed periodically as part of the operation of the system.

6) Other Treatment Considerations

As part of the design phase, additional consideration should be put towards reviewing additional treatment processes that may be required to ensure suitable water is supplied to the work camp. For example, groundwater typical for the Peace region has elevated hardness which is not compatible with some uses, such as boilers. Based on the intended potable uses within the work camps, it is likely hardness won't be an issue; however, additional consideration should be put towards whether softeners may be required to reduce hardness for unique applications. Furthermore, a more detailed review of the water quality should be undertaken during the design phase to ensure that the appropriated treatment barriers are included as part of the treatment process.

7) Treatment Buildings

As per discussions with BC Hydro staff, in the event standalone water system are selected to supply water to work camps, it is our understanding that the South Bank

Water Treatment Plant will only be operational for a period of 7 to 8 years while the North Bank Water Treatment Plant will remain in operation to supply water to the dam workers at a permanent office following the completion of the dam construction. Based on this information, it is recommended that a mobile container type water treatment plant is utilized at the South Bank Camp, while the North Bank Camp utilizes a permanent treatment building. These types of treatment plants were assumed during the cost estimate outlined below.

2.3.4 Class D Cost Estimate

The Class D cost estimate for standalone water supply and treatment systems for the North and South Bank Camps as outlined above is summarized in Table 2.2 and Table 2.3, respectively. Note that the costs to supply power to the pumps and to the water treatment plant are not included in the estimates and should be considered as part of the camp designs.

Table 2.2 - South Bank Camp Standalone Water System (Design Flow = 1,350 m^3/day)

Option	Item	Estimate
1	Surface Water Source	
	Intake in Peace River	$130,000
	Pumping Station	$520,000
	2,600 m Raw Water Supply Line	$1,680,000
	Water Treatment Building (modular)	$300,000
	Water Treatment Equipment	$900,600
	Power Supply	Not Included
	Subtotal	$3,530,600
	Engineering and Contingency (45%)	$1,588,770
	Total (Rounded)	$5,100,000
2	Groundwater Source	
	Two 200mm Wells	$385,000
	Pumping Station	$416,000
	2,600 m Raw Water Supply Line	$1,680,000
	Water Treatment Building (modular)	$300,000
	Water Treatment Equipment	$900,600
	Power Supply	Not Included
	Subtotal	$3,681,600
	Engineering and Contingency (45%)	$1,656,720
	Total (Rounded)	$5,300,000

Table 2.3 - North Bank Camp Standalone Water System (Design Flow = 600 m^3/day)		
Option	Item Description	Estimate
1	Surface Water Source	
	Intake in Peace River	$370,000
	Pumping Station	$500,000
	1,200 m Raw Water Supply Line	$450,000
	Water Treatment Building (permanent)	$350,000
	Water Treatment Equipment	$638,000
	Power Supply	Not Included
	Subtotal	$2,308,000
	Engineering and Contingency (45%)	$1,038,600
	Total (Rounded)	$3,300,000
2	Groundwater Source	
	Two 200mm Wells	$330,000
	Pumping Station	$315,000
	1,200 m Raw Water Supply Line	$450,000
	Water Treatment Building (permanent)	$350,000
	Water Treatment Equipment	$638,000
	Power Supply	Not Included
	Subtotal	$2,083,000
	Engineering and Contingency (45%)	$937,350
	Total (Rounded)	$3,000,000

A list of assumptions that accompanies the cost estimates is included in Appendix F.

2.3.5 Long Term Considerations

One of the main challenges to designing a standalone water system is the fluctuations in water demands at both camps. It is our understanding that the South Bank Camp's population will fluctuate from 0 to 1200 during the 7 to 8 year construction period while the North Bank Camp will have a relatively consistent population of 500 people throughout construction. Following the completion of construction, the North and South Bank Camps will dissolve while a small group of BC Hydro employees and contractors tasked with the operation and maintenance of the dam at the proposed dam office on the North side will rely on water being supplied from the North Bank Camp water supply system. For this reason it is recommended that both systems are designed to the water demands of both the peak populations as well as the reduced population periods. This can be accomplished by having parallel pumps and treatment trains that can be brought online or offline depending on the demands. With a better understanding of the demand fluctuations, the appropriate number of parallel trains (pumping and

treatment equipment) can be determined. Depending on the fluctuations, it may be more economical to design the treatment plants to be able to accommodate skid mounted treatment trains during peak demand. For the North Bank Camp, depending on the long term water demands, the best option may be to design the original system to accommodate the construction water demands with the ability to be retrofitted with a new water supply and treatment system to accommodate the post-construction water demands. During design, discussions with equipment suppliers should focus on the ability to scale back the capacity of the system as part of the selection of the preferred processes.

2.4 Integration with the City of Fort St. John Water System

2.4.1 Overview of City of Fort St. John Water System

The City of Fort St. John's water system was originally designed for 200 L/s. In recent years the filtration system has been retrofitted which has increased the treatment capacity; however, the water supply system is nearing capacity due to the continual population growth as a result of the extensive economic activity throughout the region. As a result of continued pressures on their water system, the City has implemented a number of water conservation measures and is in the process of reviewing the impacts of their efforts. One such measure is the implementation of water meters throughout the community. During the 2012 calendar year, the City intends to reassess the capacity of the water system to determine when major water infrastructure upgrades will be necessary. One such upgrade that has been scheduled for this summer (2012) is the development of a new well to increase the capacity of the City's groundwater source. As the population continues to increase, additional upgrades will include increasing the capacity of the High Lift Pump Station, water treatment plant and distribution system to convey the increased flows to the City's reservoirs. With this in mind, the additional flow at the North Bank Camp, estimated to have a MDD of 600 m^3/day (6.9 L/s), should be reviewed in concert with the existing capacity of the City's water infrastructure. Following the City's assessment of the existing capacity of their water system, it is recommended that a detailed discussion with the City be undertaken to identify additional system upgrades that may be required to ensure the City's water system is not compromised as a result of servicing the North Bank Camp.

2.4.2 City of Fort St. John Water System – Integration Option

As outlined in the work program, this study also considers the option of connecting to the CFSJ's potable water system in order to meet the North Bank Camp water demands. The main benefits to pursuing this option are that the City's water system provides a very reliable source of potable water and reduced operation requirements compared to a standalone potable water system. However, the City

does not typically supply water outside of their municipal boundaries and therefore an agreement must be developed with the City prior to pursuing this option further.

Based on the City of Fort St. John's existing water system, a suitable water supply connection to service the North Camp is shown in Figure 2.4. Note that an alternate route may be developed but will likely have similar infrastructure upgrade requirements.

It should also be noted that a waterworks construction permit must be received from NHA prior to connecting to the City's water supply as well as Ministry of Transportation approval to install the proposed watermains within their right-of-way.

2.4.3 Upgrades Required to Connect to the CFSJ's Water System

The upgrades required to connect to the CFSJ's water system are outlined below and are shown in Figure 2.4.

1) Install a 300mm diameter watermain loop between Tahltan and Old Fort Road (242 Road), and 100th Street and 85th Avenue. This loop is required to avoid having dead ends within the City's water system. This loop upgrade is also consistent with the long term water system upgrades required to meet the fire suppression requirements of the community as outlined in the Water Distribution System Capacity assessment report (2009).

2) Install a 300mm diameter water line from the City boundary to the start of the camp access road(at the intersection of 269 and 240 Roads) and a 100mm diameter water line along the access road to connect to the North Bank Camp's water supply system. The 300mm line was selected to provide a large enough diameter main to service properties adjacent to the supply main. The 100mm line is sized to meet the camp's maximum day water demands over a 24 hour period and is not sized for fire flows. It is understood that fire flows would be addressed as part of the reservoir design, which is not within the scope of this study. The size of the supply lines should be confirmed if this option is pursued to confirm that they meet the needs of the camp and the adjacent properties.

3) Install a water supply control system to ensure that acceptable water pressure and water flows are experienced within the supply line as well as at the North Bank Camp. The water supply control system may be developed a number of ways. Some options include a series of pressure reducing/sustaining valves or an actuated valve system that opens and closes based on water demands at the camp. A more detailed review of the appropriate water system control system should be developed based on

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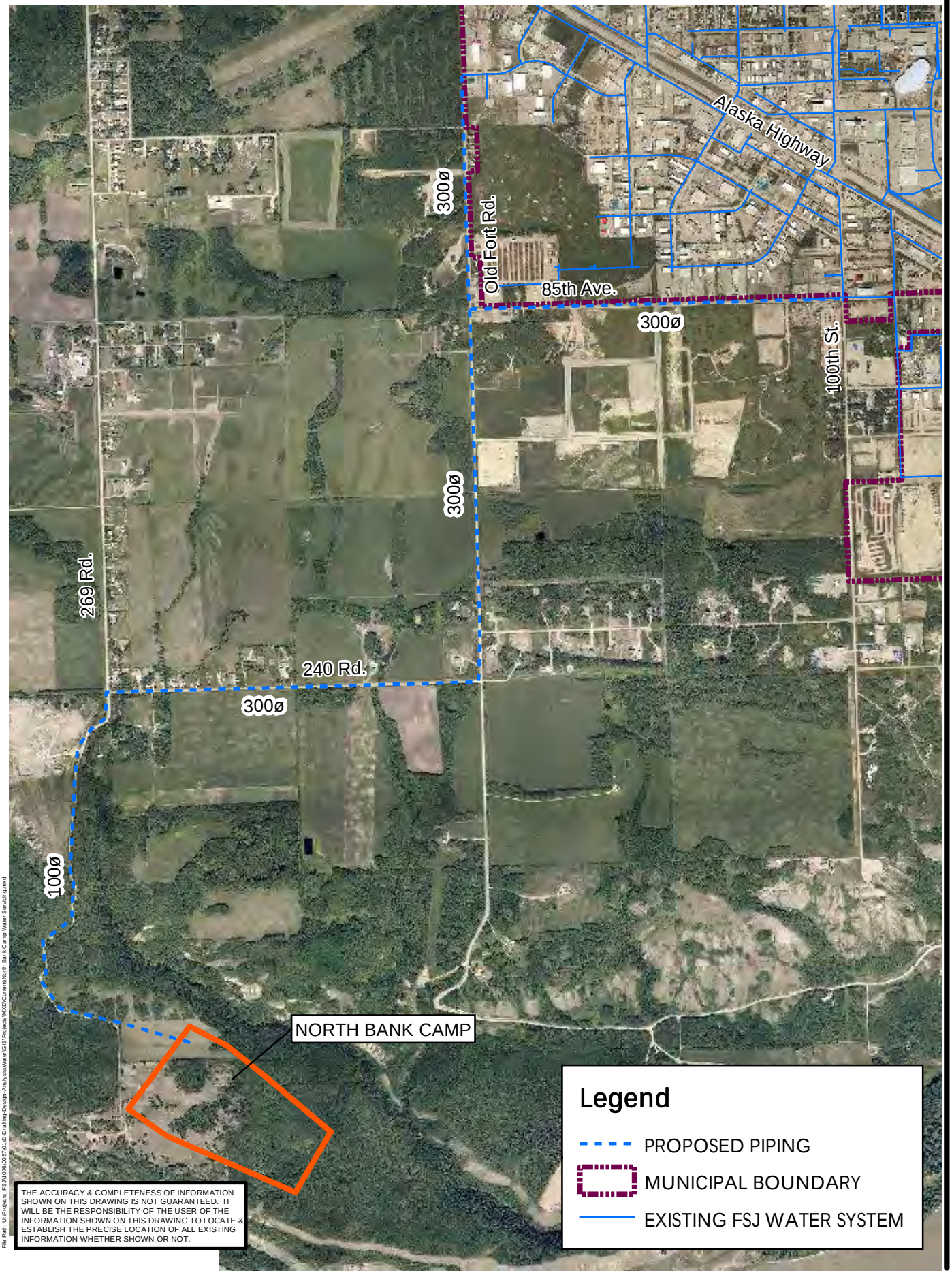

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CONNECTION TO CFSJ WATER SYSTEM

FIGURE
2.4

consultations with the City of Fort St. John and the designer of the camp storage and distribution system. For the purposes of this study, it was assumed that two pressure reducing/sustaining chambers would be required to maintain acceptable operating pressures within the supply line as shown in Figure 2.5.

This option provides service to the camp while providing benefit to the properties adjacent to the camp supply watermain. If the City requires a boundary expansion in order to provide service to the camp, a future service area and level of service for the properties would need to be defined. This could affect the sizing and layout of mains supplying the camp and should be considered in conjunction with the City if this integration option is pursued any further.

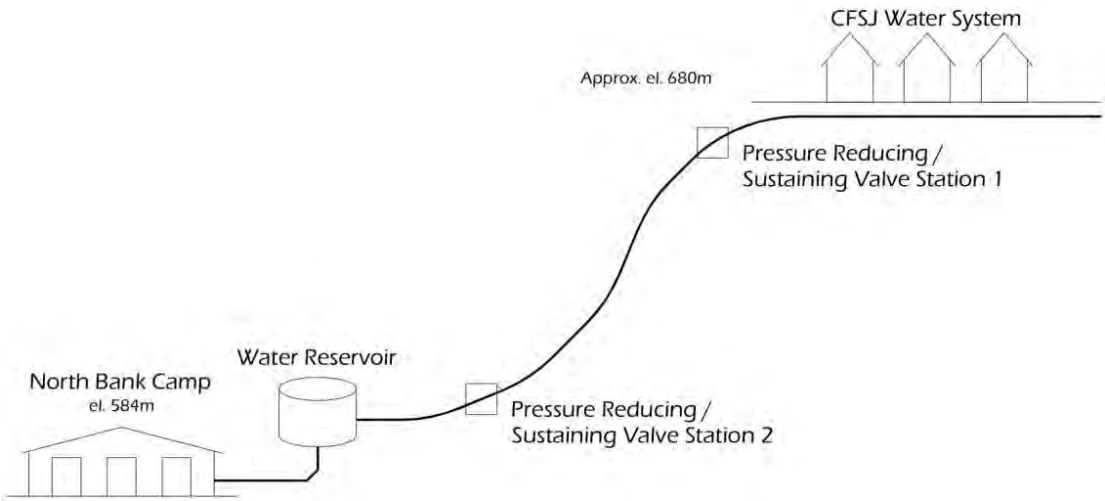

Figure 2.5 – Line diagram of water service the North Bank Camp from the CFSJ.

2.4.4 Class D Cost Estimate

Table 2.4 provides a summary of the estimated costs to supply the North Bank Camp with a water connection to the City of Fort St. John's water system. Note that both Pressure Reducing/Sustaining Stations will require a power supply to monitor them remotely and the costs below do not include the power supply to these sites.

Table 2.4 - North Bank Camp Water Servicing Connection to CFSJ Water System	
Item	Amount
2.7 km of Watermain Upgrades within City Limits	$847,000
3.2 km 300mm Water Supply Line	$864,000
2.2 km 100mm Water Supply Line	$484,000
Two Pressure Reducing/Sustaining Stations	$118,500
Electrical, SCADA and Radio Communication	$80,000
Power Supply	Not Included
Subtotal	$2,394,000
Engineering and Contingency (45%)	$1,077,300
Total (Rounded)	$3,500,000

A list of assumptions that accompanies this cost estimate is included in Appendix F.

2.4.5 Long Term Considerations

It is our understanding that the North Bank Camp water supply system may remain in operation following the completion of the dam construction to supply BC Hydro staff and contractors at the proposed dam office, although the camp itself would no longer be required. Upon completion of the dam, there will be reduced water demands which will result in increased water stagnation within the water supply line. For this reason, if a water supply line from the City's water system is pursued, it is recommended that additional thought be put into the long term operation of the supply line. Specific consideration should be given to how the water quality supplied to the camp will change over time as the water use reduces, and whether re-chlorination and/or additional preventative measures may be required to ensure that the potable water supply is not compromised at the North Bank Camp site.

2.5 Operation and Maintenance Considerations

It is recommended that the life cycle costs are reviewed as part of the selection of the preferred water supply system for the camps, which includes the operation and maintenance costs of each option. Although a detailed review of the operation and maintenance costs were not included in the scope of this study, we offer the following insight.

Based on our experience, the operation and maintenance costs for a standalone water system with a surface water and groundwater source will be similar. This assumes there are no major issues with source water quality, premature fouling of the groundwater well and/or issues with the surface water intake experiencing insufficient water supply issues such as being disconnected from the main channel of the river or sediment build-up in or around the intake. Therefore if a standalone

water system is pursued, the selection of the preferred water source should be based on the being able to secure a reliable water source (surface or groundwater) as well as the considerations discussed in Section 2.3.1.

For the North Bank Camp water supply, it is much more difficult to provide additional insight into how the operation and maintenance costs will compare between the integration option to connect to the City of Fort St. John's water system and the standalone systems. It is clear that a standalone system will require more resources to operate, including but not limited to paying for an operator, replacement parts, power, process chemicals, water quality testing. Connecting to the CFSJ's system would eliminate the need for many of these O&M costs, but the cost of the water is dependent on the CFSJ bulk water rate. At the current CFSJ bulk water rate (as of July 1, 2012), the estimated annual charge to provide the daily camp water required for workers (not including replenishing any water stored for firefighting or any costs for additional system upgrades) is $388,000. This bulk water rate is subject to change and could increase substantially during the lifespan of the camp. Therefore, although it appears as though a standalone system will have a higher operation and maintenance cost, depending on water demand and the bulk water rates, it is likely that the margin between the two supply options may not be as large as one might anticipate.

In addition, the cost to operate and maintain a standalone system post dam construction, depending on the water demands, will likely be very high per cubic meter of water and should also be considered as part of the analysis. It may be determined that operating a standalone system during construction is beneficial, but, due to low water demands and the high overhead of operating a standalone system, post construction the standalone system is decommissioned and the long term water supply is achieved by hauling bulk water to site.

3.0 SANITARY WASTEWATER SYSTEM

As outlined in our work program included in Appendix A, an analysis of sanitary wastewater integration options with the Peace River Regional District (PRRD) and the CFSJ has been prepared. For integration with each party we have provided:

- A review of their existing infrastructure and treatment capabilities;
- A primary integration option for each the PRRD and the CFSJ's wastewater systems, with design considerations and a Class D cost estimate; and,
- Lists of other integration options, for which considerations were included but cost estimates were not prepared.

In concert with the information presented in this study for wastewater servicing, it is also recommended that additional consideration is put towards the costs of hauling wastewater offsite as well as the costs to develop a standalone system prior to selecting the preferred wastewater servicing option. The life cycle costs of the various options should be compared.

Calculations provided by BC Hydro were developed using The US Army Corps of Engineers – Domestic Wastewater Treatment Mobilization Construction (May 1984). Cost estimates and integration options are based on information provided by BC Hydro, most notably:

- Average Daily Flow 280 m^3/day (3.2 L/s)
- Maximum Day Flow 840 m^3/day (9.7 L/s)

For all integration options, it is assumed that the North Bank Camp wastewater wet well elevation is 570 m. A complete list of assumptions and design flow calculations are included in Appendix G.

3.1 Integration with the Peace River Regional District

3.1.1 Overview of Existing PRRD System

The PRRD operates a wastewater treatment facility to treat wastewater from the Charlie Lake Community Sewer Systems (CLCSS) which is located approximately 10 km north west from the North Bank Camp at an elevation of 733 m. The original system was constructed in 1991 and designed to collect and treat wastewater effluent from approximately 580 lots in the Charlie Lake area. It has a treatment capacity of 3.9 L/s.

Treatment at the CLCSS Lagoons occurs by natural aeration caused by wind action. Effluent first passes through an anaerobic cell, then a treatment cell, and finally enters a storage cell as treated effluent. Depending on the time of year, the treated

effluent is held within the storage cell or it is discharged to the Peace River via the PRRD's outfall line.

The PRRD's discharge permit, issued in 1994, is governed by an Operational Certificate issued by the BC Ministry of Environment, Lands and Parks. The certificate allows for discharge to occur from July 1 – October 31 (123 days) with a maximum discharge rate of 3,000 m^3/day. It is due to this seasonal discharge limit that a storage cell at the Charlie Lake Lagoons is used to hold treated effluent during the 8 months when discharge is not permitted.

Due to the CLCSS Lagoons design to treat effluent only, each user has a septic tank that operates as primary treatment to collect settleable solids. All individual service connections are responsible for primary treatment in order for the system to operate as intended.

Presently, residents from the Charlie Lake area contribute an average annual flow of 3.6 L/s to the Charlie Lake Lagoons. This flow does not include additional flows that are contributed to the lagoons as a result of precipitation. Since the flow is not measured at the outfall of the lagoons, it is assumed that the lagoons are very close to capacity and do not have very much excess capacity. Before additional services are connected to the existing system, it is recommended that treatment and storage upgrades requirements are reviewed in greater detail. Table 3.1 summarizes capacity and design values pertaining to the Charlie Lake Lagoons, as well as compares the impacts to the system if the North Bank Camp discharges effluent to the system.

Table 3.1 – CLCSS Capacity and Design Flows	
2011 Annual Average Flow Recorded at CLCSS Lift Station	3.6 L/s
Treatment Capacity of CLCSS	3.9 L/s
Capacity of Outfall Line	34 L/s
Discharge Permit (average over year)	11.6 L/s
Current Flow + North Bank Camp Average Day Flow	*6.7 L/s*
Current Flow + North Bank Camp Max Day Flow	*13.2 L/s*

While there remains capacity within the discharge line and discharge permit, storage and treatment capacities are limited. The additional flow rates to the Charlie Lake Lagoons from the North Bank Camp will exceed the available treatment capacity.

3.1.2 Primary Integration Option with PRRD

If BC Hydro partners with the PRRD to treat their wastewater at the Charlie Lake Lagoons, the primary integration option for sewage treatment would likely be configured as follows (see Figure 3.2):

1. Wastewater flows from North Bank Camp by gravity to onsite primary treatment facility to remove solids. Primary treatment will require a very large septic tank, approximately 550 m³, with a baffle such that solids can settle out.
2. On site pump station uses effluent pump to transfer sewage by forcemain, approximately 9,900 m, to the Charlie Lake Lagoons.
3. Sewage is treated at the Charlie Lake Lagoons and discharged to the Peace River.

This process is summarized visually in Figure 3.1.

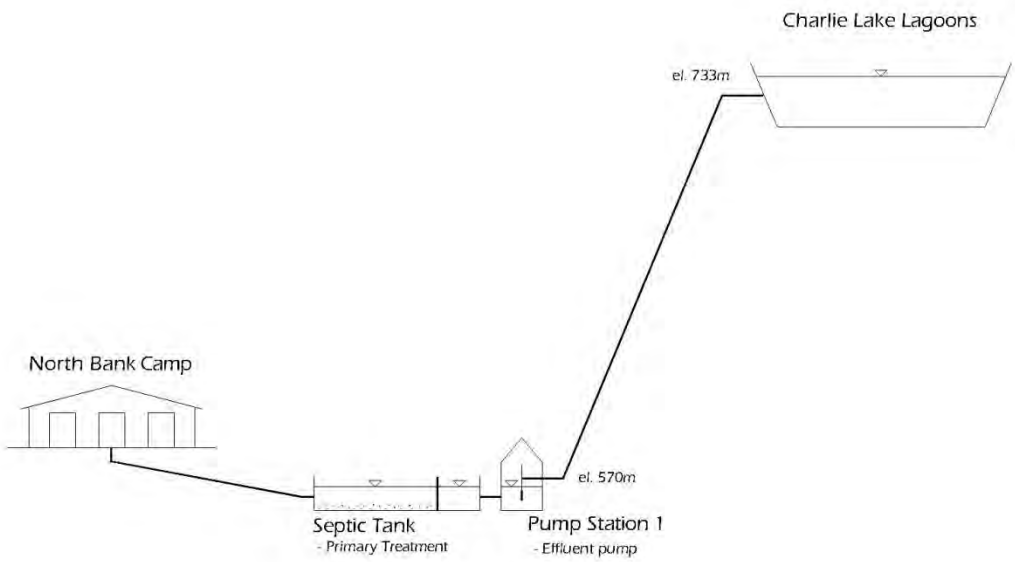

Figure 3.1. Line diagram of a likely configuration for transporting effluent from the North Bank Camp to PRRD's Charlie Lake Lagoons.

3.1.3 Considerations

As primary treatment settles out solids from the wastewater, regular cleanout of the septic tank will be necessary to ensure the system operates as intended. The solids will need to be periodically removed and hauled to a treatment or disposal facility. Odours may also be an issue due to the use of a septic tank. Table 3.2 contains a Class D Construction Cost Estimate for this integration option.

Additional costs will likely be incurred by BC Hydro to upgrade the Charlie Lake Lagoons to accommodate increased sewage flows created by this option. These

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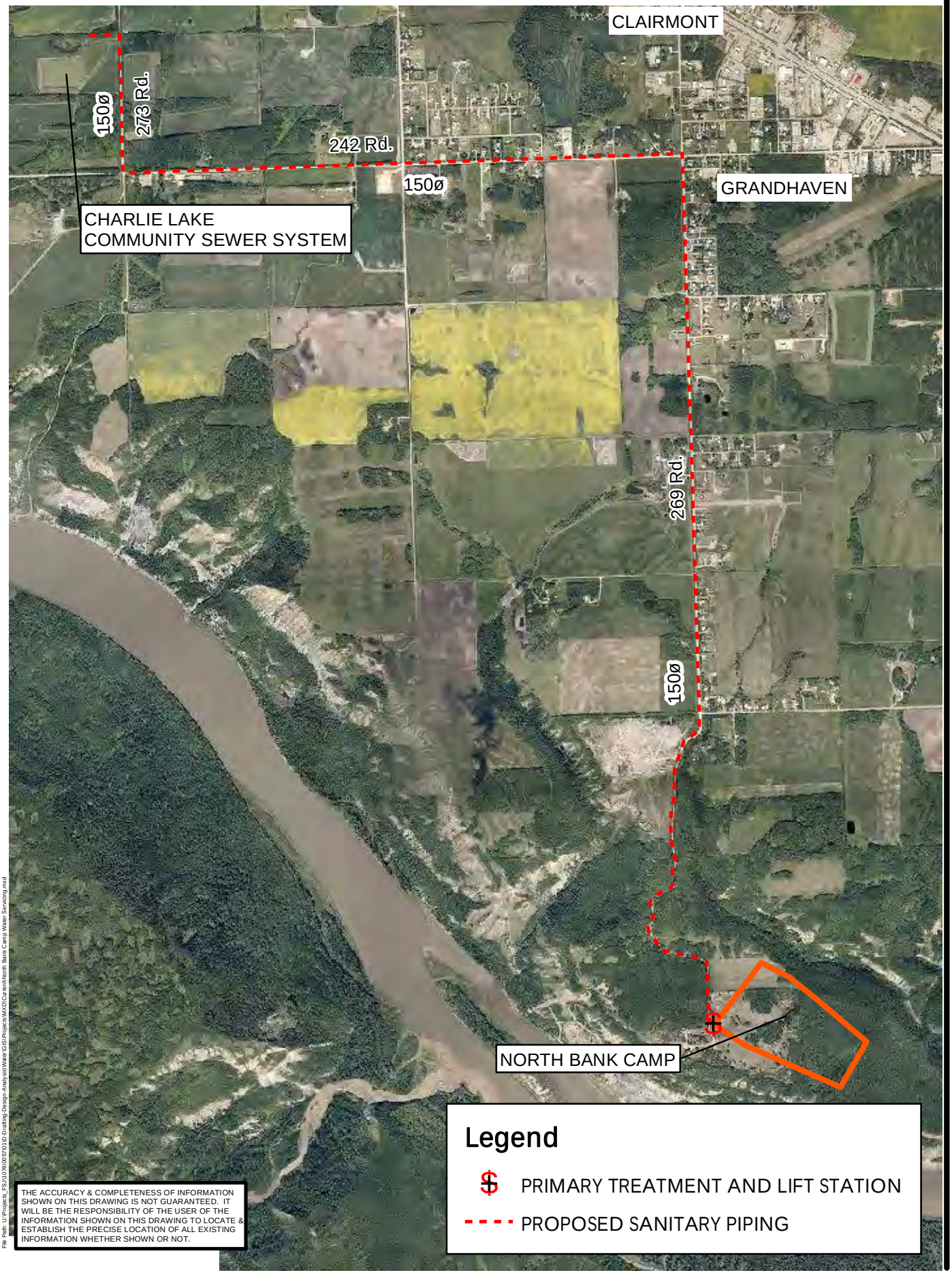

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SANITARY SERVICING TO PEACE RIVER REGIONAL DISTRICT CHARLIE LAKE LAGOONS

FIGURE
3.2

additional costs are not included in the cost estimate as it has been determined that upgrades and cost sharing between BC Hydro and the PRRD are beyond the scope of this study. Treatment, storage, and discharge upgrades will likely be required.

Foreseeable upgrades to the treatment process of the lagoons include adding aeration, baffles, a complete mix tank, and deepening the lagoons. To aerate the lagoons, a blower building – complete with blowers, aeration piping, and electrical servicing – is required.

Upgrades to the storage and discharge aspect could either include:

- Increasing storage capacity and increasing the duration of the discharge permit window; or,
- Applying to the Ministry of Environment for a permit amendment to allow for continuous, year-round, discharge to the Peace River.

The application for a continuous discharge permit will likely require an Environmental Impact Assessment (EIA) and registration with the Municipal Sewer Regulation (MSR).

Consideration for the long term flow situation should not be overlooked. Under low flow situations, forecasted at the end of construction, wastewater could remain in the septic tank and pump station wet well for extended periods of time. Long detention times could cause odour issues, freezing issues, solids to settle in the pump station wet well, wastewater to turn septic, and the frequency of pump operation to decline. Reduced wastewater quality could also affect the treatment process in the Charlie Lake Lagoons.

3.1.4 Class D Cost Estimate

This Class D Construction Cost Estimate for integration with the PRRD, as outlined in section 3.1.2, is summarized in Table 3.2. Note that this cost estimate does not include the power supply requirements.

Table 3.2 – North Bank Sanitary Servicing Integration with PRRD

Item	Amount
Sewage Pretreatment Facility	$230,000
Pump Station - supply and installation	$270,000
Electrical and SCADA	$120,000
150 mm Forcemain including appurtenances	$2,228,000
Power Supply	Not Included
Subtotal	$2,848,000
Contingency & Engineering (45%)	$1,282,000
Total	$4,130,000

A list of assumptions that accompanies this cost estimate is included in Appendix G.

3.1.5 Other Integration Options

a) Offset Upgrade Costs

Currently the PRRD is reviewing options to provide sewer service to the Grandhaven and Clairmont (G&C) subdivisions due to environmental concerns and development pressures. All the residents living in these subdivisions dispose of their wastewater through on-site disposal systems. Due to poor soil conditions, high groundwater tables, and poor operation and maintenance, many of these systems do not operate as intended. As a result, they now pose an environmental hazard to both local surface and groundwater sources. During the past 10 years, the PRRD has investigated numerous ways to service these subdivisions with a community sewer system to address the environmental concerns. To date, a community sewer system is not installed in these subdivisions due to the financial costs of constructing such a system.

If the PRRD chooses to provide sewer service to G&C using the Charlie Lake Lagoons, upgrades to the lagoons to accommodate increased flows will be necessary. If both G&C and BC Hydro discharge wastewater to the Charlie Lake Lagoons, perhaps a partnership could be explored to offset treatment upgrade costs for all parties. This would be a discussion item for the PRRD and BC Hydro moving forward in this project.

b) Creation of a New Outfall Line

The present outfall line from the Charlie Lake Lagoons discharges into the Peace River upstream of the proposed Site C Dam. Construction of the Site C Dam will have an impact on this outfall line due to the water elevation rising within the reservoir. It is possible the existing outfall line will have to be modified or rerouted.

If the outfall line is re-routed, such that the discharge location is relocated downstream of the Site C Dam near the North Bank Camp, an option for the North Bank Camp to also use the outfall line could arise. This option would require a standalone on-site wastewater treatment for the North Bank Camp and possibly a pump station to transport treated effluent to the outfall line. There will be no costs to upgrade treatment or storage at the Charlie Lake Lagoons as the North Bank Camp will independently treat its own wastewater.

c) Create a New Wastewater Treatment System for G&C and North Bank Camp

If the PRRD is interested in providing a sanitary sewer system to the G&C subdivisions, a new wastewater treatment system could be created to treat wastewater from both G&C and the North Bank Camp. In this configuration, wastewater collected from G&C would flow through a new line south to the North Bank Camp where a new treatment system would be located. The treated wastewater would then be discharged to the Peace River via a new outfall line.

d) Integrate for the Long Term Flow Situation

Currently we have focused on providing pumping solutions that will transfer the maximum day demand flows during peak camp population (first 7 to 8 years of construction). A pumping solution could be designed to accommodate a lower camp population – a value closer to the operational population of the office upon completion of the dam. This would decrease the pumping and treatment requirements by approximately one order of magnitude (i.e. 500 people to 50 people). To supplement wastewater volumes during peak camp populations, other alternatives such as hauling by trucks to an alternative treatment centre could be implemented. A life cycle cost evaluation and comparison is suggested to determine if this is an economically feasible option.

3.2 Integration with the City of Fort St. John

3.2.1 Overview of Existing CFSJ System

The City of Fort St John (CFSJ) collects users' wastewater, primarily by gravity, and treats it either at the North Lagoons or the South Sewage Treatment Plant (SSTP). Both facilities are capable of treating wastewater containing solids.

Located approximately 7 km north east of the North Bank camp at an elevation of 674 m, the SSTP is the closest CFSJ operated treatment facility. This facility consists of two complete mix tanks, one blower building, and two aerated lagoons.

The volume of wastewater the SSTP is designed to handle is 25,000 m^3/day during peak hour flows, 15,000 m^3/day during maximum daily flows, and 8,000 m^3/day during average day flows. The SSTP has a continuous discharge permit that allows for a maximum discharge of 15,000 m^3/day, governed by an Operational Certificate issued by the BC Ministry of Environment, Lands and Parks.

In 2010, operating data at the SSTP revealed average inflows near 4,800 m^3/day (56 L/s), a maximum month flow near 5,700 m^3/day (66 L/s), and a maximum day flow near 10,900 m^3/day (126 L/s). These flows are affected by fluctuations in weather, and therefore can vary significantly from year to year.

Typical wastewater enters the SSTP by this process:

1. Wastewater flows by gravity to the South Lift Station.
2. Pumps at the South Lift Station transfers wastewater via a forcemain to either of the two complete mix tanks.
3. The wastewater continues its final treatment process in either of the two aerated lagoons.
4. The treated effluent is discharged into the Peace River.

3.2.2 Primary Integration Option

Due to low design flows and high elevations to overcome, few options exist to transport wastewater from the North Bank Camp to the CFSJ South Lagoons. One possible configuration requires a series of two lift stations in a 'leap frog' system. A leap frog system is where one pump station transfers wastewater via forcemain to another lift station – and the process continues as necessary. It is a method to overcome pumping against high elevation changes. The total length of the forcemain will be approximately 7,400 m. A schematic of this pumping configuration is illustrated in Figure 3.3.

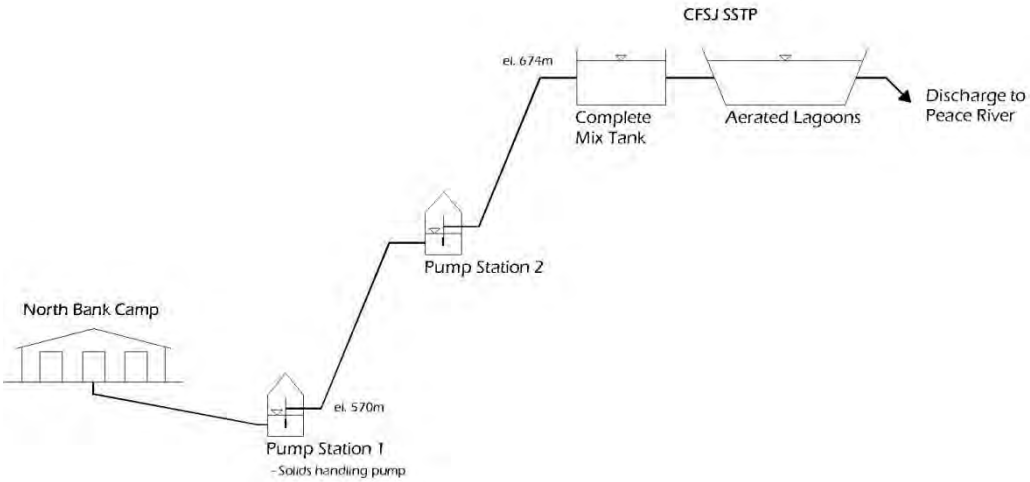

Figure 3.3 – A line diagram representing the pumping configuration to transport wastewater containing solids to the City of Fort St. John South Sewage Treatment Plant (CFSJ SSTP).

This option assumes wastewater is to be directly discharged to Control Manhole #1 – located immediately before the Complete Mix Tanks. It is one of the shortest routes to the SSTP and will bypass the City's gravity system. One possible route connecting the South Lagoons and the North Bank Camp is illustrated in Figure 3.4.

3.2.3 Considerations

This option was chosen as the primary integration option due its ability to handle wastewater containing solids. No septic tank or hauling of settleable solids is necessary with this option – this reduces onsite footprint and odour issues that could be problematic with a large septic tank.

However, this option does require two independent pump stations. Operation and maintenance for multiple stations will be required. A three phase power source is also a requirement for pump operation; this power source is not included in the cost estimate.

Consideration for the long term flow situation should not be overlooked. Under low flow situations, forecasted at the end of construction, wastewater could remain in the pump station wet well for extended periods of time before being pumped. Long detention times could cause odour issues, freezing issues, solids to settle in the pump station wet well, wastewater to turn septic, and the frequency of pump operation to decline.

While it appears that during 2010 the City did not exceed the design capacity of the SSTP, sewage flow volumes and quality can vary significantly. The addition of flows from the North Bank Camp would impact the available capacity at the SSTP,

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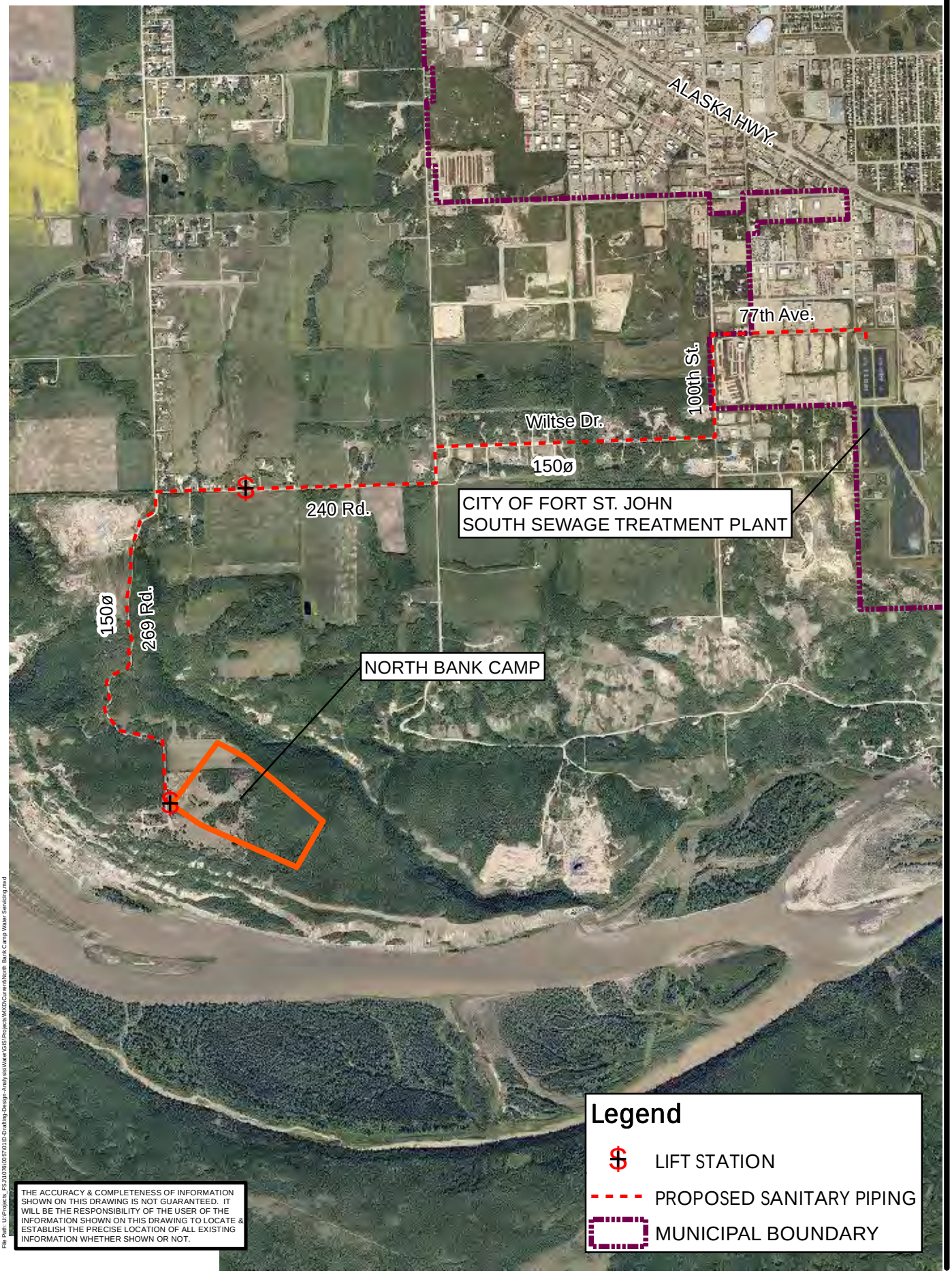

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SANITARY SERVICING TO CITY OF FORT ST. JOHN SOUTH SEWAGE TREATMENT PLANT

FIGURE

3.4

resulting in the need for upgrades earlier than may otherwise have been planned by the CFSJ. Costs for upgrades or connection charges will likely arise for accepting and treating the wastewater, but these will have to be determined in discussion with the City. These additional costs are not included in the cost estimate as it has been determined that upgrades and cost sharing between BC Hydro and the CSFJ are beyond the scope of this study.

The CFSJ does not typically allow servicing outside of their municipal boundaries. An agreement must be developed with the City prior to pursuing this option further. If the City determines a boundary expansion is required, it is recommended to work with the City to consider whether the servicing option for the camp could be modified to allow for future servicing of adjacent properties. For example it may be possible to upsize the forcemain, provide two parallel mains, or strategically place lift stations.

3.2.4 Class D Cost Estimate

This Class D cost estimate for integration with the CFSJ, as outlined in section 3.2.2, is summarized in Table 3.3. Note that this cost estimate does not include the power supply requirements.

Table 3.3 – North Bank Sanitary Servicing Integration with CFSJ

Item	Amount
Two Pump Stations - supply and installation	$596,000
Electrical and SCADA	$160,000
150 mm Forcemain including appurtenances	$1,665,000
Power Supply	Not Included
Subtotal	$2,421,000
Contingency & Engineering (45%)	$1,089,000
Total	$3,510,000

A list of assumptions that accompanies this cost estimate is included in Appendix G.

Operations and maintenance costs should also be considered when selecting the preferred method for servicing the camp. As an example, if integration with the CFSJ was chosen as the preferred servicing method, using the current CFSJ bulk sewer rate (as of July 1, 2012), the estimated annual charge for receiving sewage from the North Bank Camp is $460,000 per year (not including any costs for additional system upgrades). It is expected this rate will increase over time.

3.2.5 Other Integration Options

a) Effluent Only Connection

Instead of using multiple solids handling pump stations in a leapfrog configuration, a single effluent pump station could be used. This option would require a septic tank at the North Bank Camp to provide primary treatment to the wastewater such that an effluent pump could be used. The solids that settle in the septic tank would periodically require removal. A continuous forcemain would connect the North Bank Camp to the SSTP.

This configuration would be similar to one proposed for the PRRD (Figure 3.2).

b) Connection to Gravity System

Options to pump into existing CFSJ sanitary sewer mains are limited. Sanitary sewer mains in the southwest area of Fort St. John are near/at capacity and sensitive to increasing flow and therefore cannot accommodate BC Hydro flows without significant upgrades. Further, based on our findings, a minimum of two solids handling pump stations will still be required to overcome elevation changes between the North Bank Camp and CFSJ.

4.0 CONCLUSIONS

Based on servicing options reviewed as part of this study, the costs for the options to provide potable water and sanitary servicing to the North Bank Camp and potable water servicing only to the South Bank Camp are summarized below.

4.1 North Bank Camp Water Servicing Options

A summary of the three servicing options for potable water for the North Bank as well as the class 'D' construction cost estimates and a synopsis of the advantages and disadvantages for each option are included below:

1) Standalone Water Supply System (Surface Water Source)

This option includes the installation of a surface water intake on the north side of the Peace River with two parallel submersible pumps that lift water up to a water treatment plant within the North Bank Camp boundary. The treatment building is a permanent building with a treatment process that includes coagulation, flocculation, filtration, UV disinfection and chlorination. The process is sized to deliver 600 m^3/day of potable water to the North Bank Camp. This option does not include any costs associated with site access or power supply to the treatment building.

Cost Estimate $3.3 million
Advantage: Known water source (quality and quantity)
Disadvantage: Potentially long permit/approval process from regulatory agencies and increased risk of water source being compromised by upstream activities.

2) Standalone Water Supply System (Groundwater Source)

This option includes the installation of a two parallel groundwater wells on the north bank of the Peace River valley. The submersible pumps are sized to lift water up to a water treatment plant within the North Bank Camp boundary. The treatment building is a permanent building with a treatment process that includes chemical pre-treatment (oxidation), filtration, UV disinfection and chlorination. The process is sized to deliver 600 m^3/day of potable water to the North Bank Camp. This option does not include any costs associated with site access or power supply to the treatment building.

Cost Estimate $3.0 million
Advantage: Reduced permitting and approval time required and more consistent treatment process (reduced water quality fluctuations)

Disadvantage: Risk of not finding a suitable groundwater source

3) Connect to City of Fort St. John Water System

This option includes a water connection to the City of Fort St. John's existing water system. A watermain loop within the municipal boundaries is included in the option to avoid dead-ends within the water system. From the municipal boundary a smaller diameter water supply line extends to service the North Bank Camp. Two pressure reducing/sustaining stations are included in this option to ensure suitable water pressure is delivered to the North Bank Camp. This option does not include any costs associated with site access or power supply to the pressure reducing/sustaining stations and does not include any re-chlorination equipment.

Cost Estimate: $3.5 million

Advantage: Reduced operational requirements (no treatment), very reliable water supply and contributes to City's long term water system upgrade requirements.

Disadvantage: Unknown costs to connect to City. Special agreement may need to be developed with City to service outside City boundaries which may require additional capital investment from BC Hydro to accommodate future system upgrades or expansions.

4.2 South Bank Camp Water Servicing Options

A summary of the two standalone potable water system options to service the South Bank Camp with potable water as well as the class 'D' construction cost estimates and a synopsis of the advantages and disadvantages for each option are included below:

1) Standalone Water Supply System (Surface Water Source)

This option includes the installation of a surface water intake on the south side of the Peace River with two parallel submersible pumps that lift water up to a water treatment plant within the South Bank Camp boundary. The treatment building is a modular building with a treatment process that includes coagulation, flocculation, filtration, UV disinfection and chlorination. The process is sized to deliver 1,350 m^3/day of potable water to the South Bank Camp. This option does not include any costs associated with site access or power supply to the treatment building.

Cost Estimate: $5.1 million

Advantage: Known water source (quality and quantity)

Disadvantage: Potentially long permit/approval process from regulatory agencies and increased risk of water source being compromised by upstream activities.

2) Standalone Water Supply System (Groundwater Source)

This option includes the installation of two parallel groundwater wells on the south bank of the Peace River valley. The submersible pumps are sized to lift water up to a water treatment plant within the South Bank Camp boundary. The treatment building is a modular building with a treatment process that includes chemical pre-treatment (oxidation), filtration, UV disinfection and chlorination. The process is sized to deliver 1,350 m^3/day of potable water to the South Bank Camp. This option does not include any costs associated with site access or power supply to the treatment building.

Cost Estimate: $5.3 million
Advantage: Reduced permitting and approval time and more consistent treatment process (reduced water quality fluctuations)
Disadvantage: Risk of not finding a suitable groundwater source

Prior to proceeding into design, it is recommended that river hydraulics and groundwater specialists are consulted to confirm the assumptions of this study for both the North and South Bank water servicing options. Furthermore, it is recommended that life cycle costs be taken into consideration as part of further feasibility analysis and design which will include reviewing the water rates and service connection charges for the North Bank Camp to connect to the City of Fort St. John's water system. It is also recommended that additional servicing options are considered, such as hauling potable water (which was beyond the scope of this report) to ensure that all possible options for potable water servicing are considered prior to detailed design.

4.3 North Bank Camp Sanitary Wastewater Service Options

A summary of the two primary wastewater integration options reviewed as part of this study are included below. We have also included some additional considerations that we feel may be important to consider or study further should an integrated option be considered for wastewater servicing for the North Bank Camp.

1) Connection to PRRD's Charlie Lake Lagoons

This option includes the installation of a pre-treatment system (septic tank) to collect the solids prior to the wastewater being transported via a lift station and force main to the Charlie Lake Lagoons. This option does not include the upgrade costs to the Charlie Lake Lagoons as it was not considered part of

the scope of this project. Please also be advised, that this system does not currently have capacity to add the anticipated flows from the North Bank Camp and upgrades to this system would be required.

Cost Estimate: $4.1 million
Advantage: One pump station.
Disadvantage: Requires septic tank maintenance, possible odours, large footprint for septic tank, upgrades to CLCSS

2) Wastewater Connection to CFSJ's Wastewater System

This option includes the installation of a number of lift stations in a leapfrog style to transport the wastewater through a force main to the existing lagoons at the City of Fort St. John. This option does not include the upgrade costs to the City's lagoons as it was not considered part of the scope of this project. Please be advised that this system currently does have capacity to accommodate the additional flows from the North Bank Camp, however approval would be required from the City prior to any connections taking place.

Cost Estimate: $3.5 million
Advantage: No septic tank or septic tank maintenance.
Disadvantage: Operation and maintenance costs for two pump stations, three phase power supply at two pump station locations.

It may also be beneficial to explore future partnerships with the City and the Peace River Regional District to ensure upgrades will be mutually beneficial to both the local residents and BC Hydro. Some mutually beneficial topics for discussion identified in this study include:

- Sizing upgrades to the Charlie Lake lagoons to meet the ultimate design capacity for the neighbouring Grandhaven and Clairmont subdivisions and the North Bank Camp;
- Aligning any upgrades to the Charlie Lake outfall which may need to be relocated as a result of the dam construction so that it aligns with potential standalone wastewater processes for the North Bank Camp; and
- Creating a new wastewater treatment system that may accommodate the long term needs of the PRRD (Grandhaven and Clairmont subdivision) and the North Bank Camp.
- Sizing water and sewer camp supply mains and modifying pipe layouts to accommodate adjacent properties that may be incorporated into the City boundary along with the North Bank Camp and require service in the future.

Furthermore, it is recommended that life cycle costs be taken into consideration as part of the selection of the preferred wastewater servicing option. Also, although they were not reviewed as part of this study, it is recommended that the life cycle costs for a standalone systems as well as hauling all wastewater offsite are reviewed in greater detail to ensure that all long term wastewater servicing options are considered prior to proceeding into detailed design. This will ensure that the wastewater servicing needs of the camps are provided in a cost effective manner alongside additional considerations for integration with the neighbouring communities.

Site C Camps
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APPENDIX A

Urban Systems Ltd Work Program

1076.0057.01 / May 24,
2012

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10808 – 100 Street, Fort St. John BC V1J 3Z6
Telephone: 250-785-9697

December 21, 2011 File: 1076.0057.00

BC Hydro
1055 Dunsmuir Street, 11th Floor
Vancouver, BC V7X 1V5

VIA EMAIL: erin.harlos@bchydro.com

Attention: Erin Harlos, Socio Economic Lead

RE: Site C North Bank Site – Sanitary Sewer & Potable Water – Engineering Feasibility Assessment – Revised Scope

Thank you for providing us the opportunity to submit a work program and fee estimate for the review of the technically feasible options for servicing the proposed North Bank site with potable water and sanitary sewer. We have revised our work program again to reflect the changes in scope outlined in your email on December 19, 2011. We are looking forward to applying our knowledge of the local area as well as our understanding of existing water and sanitary sewer infrastructure for both the City of Fort St. John (CFSJ) and the Peace River Regional District (PRRD) as part of this project. The following outlines our understanding of the project scope. It also introduces our work program, key assumptions, and our allocated budget and schedule.

PROJECT UNDERSTANDING

As outlined in the Contract Scope Outline provided by BC Hydro dated November 14, 2011, this project entails determining the technically feasible options available to provide potable water and sanitary sewer servicing at the proposed North Bank site. The assessment will include consideration of:

- Service requirements of worker accommodations during Site C dam construction;
- Service requirements of long term offices post construction;
- Planning of future water and sewer infrastructure in the region including the CFSJ and PRRD systems; and
- Our local knowledge the CFSJ and PRRD water and sewer infrastructure.

As requested by BC Hydro, at this time, the scope of this assessment no longer includes the following items:

- Standalone sewer systems;
- Partial & total haul sewer options;
- Water haul options; and
- Sustainability options for servicing and infrastructure planning.

WORK PROGRAM

1.0 Sanitary Sewer Servicing Options Assessment

The sanitary sewer assessment will consider integration options for extending PRRD or CFSJ infrastructure. Coordination with BC Hydro will be required to compile any additional background information about the site and design flow requirements. Our sewer servicing review will be limited to treatment and disposal options and will not consider collection system requirements within the North Bank site itself.

1.1 Standalone Systems

A review of self sufficient, standalone systems is no longer part of the scope of work.

1.2 Haul Options

A review of the feasibility of hauling all of the site's sewage to the CFSJ or PRRD's systems is no longer part of the scope of work.

1.3 Integration Options

In completing the sanitary sewer review we will consider whether it is feasible to extend either the CFSJ or PRRD's infrastructure to the proposed North Bank site. We will meet with both the CFSJ and PRRD staff to discuss any options that could meet the needs of the proposed North Bank site and benefit current and/or future infrastructure and development in the area. Based on our local knowledge and coordination with CFSJ and PRRD staff we will review the capacity of their systems to handle sewage from the site and identify any potential upgrades required. We will consider whether the quality of the sewage affects the ability for the City or PRRD to accept the sewage.

We will summarize the options considered. A high level Class D cost estimate will be prepared for 1 technically feasible option for connection to the CFSJ and 1 for the PRRD (if there are any options available). A Class D estimate is a preliminary estimate, based on little or no site information and represents order of magnitude costs only.

2.0 Potable Water Options Assessment

The water servicing assessment will consider standalone water supply and treatment options for the North and South Bank sites. Options for extending the CFSJ's water system will be reviewed for the proposed North Bank site only. The PRRD does not currently have a potable water system in the adjacent area. Coordination with BC Hydro will be required to compile any additional background information about the site, water consumption estimates and fire flow requirements. Our water servicing review will focus on options for getting potable water to the site, but will not consider types or volumes of reservoir storage or water distribution system requirements within the proposed North and South Bank sites. We can review these components if BC Hydro would like to add them to the scope of the project.

2.1 Standalone Systems

For standalone water systems to service the North Bank and South Bank sites we will:

- Consider available water sources at the sites;
- Review the options available to treat water to meet the BC Drinking Water Protection Act and Regulation, Guidelines for Canadian Drinking Water Quality and any other requirements from Northern Health; and
- Provide Class D cost estimates for 1 or 2 preferred options for each site.

For the North Bank site, the long term operability of the water treatment system at lower volume requirements post construction will also be considered.

2.2 Haul Options

An option for hauling potable water to the North Bank site from the CFSJ is no longer part of the scope of this review.

2.3 Integration Options

Options for extending CFSJ water infrastructure to the proposed North Bank Site will be explored. We will meet with CFSJ staff to discuss potential options and connection points that could provide BC Hydro with service and improve the City's water network or benefit future development in the area. We will apply our knowledge of the City's system to review the capacity of their system to support domestic and fire fighting requirements for the proposed North Bank development and identify any potential upgrades required. A Class D cost estimate will be prepared if a technically feasible option is available.

An overall report summarizing the potable water servicing options available will be prepared. Class D cost estimates will be included to facilitate comparison between options.

KEY ASSUMPTIONS RE: SCOPE OF WORK, BUDGET & SCHEDULE

- System options will be determined based on estimated sanitary flow and water requirement information provided by BC Hydro. We will discuss these design flows with BC Hydro staff to confirm the assumptions on how they were calculated, but we will not be revising the numbers or recalculating our own design flows.
- Field site assessments such as geotechnical studies, topographic survey, test water wells, or water quality assessments are not included as part of this feasibility assessment.
- Liaising with government agencies such as Northern Health Authority or BC Ministry of Environment to confirm if particular water treatment or sewage disposal options are acceptable is not part of the scope of work.
- Review of any potential piping alignments will only show preliminary approximate routing based on review of air photos and CFSJ 1m interval contour mapping.
- The project schedule assumes approval of this work program within 2 business days of receipt. The schedule also assumes that information and answers to any questions from BC Hydro, the

CFSJ and the PRRD will be provided in a timely fashion. Any delay may result in an increase in the time required to complete this project.

- Any changes to the outlined scope of work will require an adjustment to our fees. If any changes are requested or identified, an estimate outlining any changes to the fees and/or schedule would be submitted for approval prior to the work proceeding.

PROJECT TEAM

The project team will be led by Kristin Bayet, P. Eng. in our Fort St. John office. Kristin has worked extensively with the CFSJ and PRRD over the past 8 years on feasibility studies, overall system analytical modelling, water and sewer rate studies and infrastructure design and construction projects. Kristin is very familiar with the local infrastructure and has an understanding of what the needs of the local area are.

Kristin will be assisted by a team of professionals who will bring their technical expertise as well as their knowledge of the systems in the CFSJ and surrounding area to this project. Adam Greenwood, E.I.T. and Chad Carlstrom E.I.T. will be responsible for researching water and sewer servicing options and preparing cost estimates. Jaime Adam, P. Eng and Brian Hobbs, P. Eng will provide senior review for this project. Additional support will be provided by our Fort St. John office resources.

SCHEDULE

We are prepared to begin work on this project immediately upon your approval. A draft report would be available for review with BC Hydro staff by February 17, 2012.

We look forward to working with BC Hydro on this project. If you have any questions or comments, please feel free to contact us at your convenience.

Sincerely,

URBAN SYSTEMS LTD.

Kristin Bayet, P. Eng.
Project Engineer

Jaime Adam, P. Eng.
Project Engineer

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APPENDIX B

NHA Drinking Water Treatment Objectives

1076.0057.01 / May 24,
2012

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northern health

Public Health Protection
4th floor - 1600 Third Avenue, Prince George, BC V2L 3G6
Telephone: (250) 565-2150, Fax: (250) 565-2144, www.northernhealth.ca

Northern Health Drinking Water Treatment Objectives

Introduction

Under the Drinking Water Protection Act (DWPA), water suppliers are required to provide potable water to all users on their systems. Treatment requirements are site specific and risk based. This paper provides a framework on how Northern Health could implement the requirement of the Act related to treatment to provide microbiologically safe drinking water. The drinking water officers will have to consider various factors in allowing the water suppliers a suitable time frame to arrive at the treatment objectives.

Background

Section 6 of the DWPA requires water supply systems, except small water systems with point-of-entry or point-of-use (POE/POU) treatment units, to provide water that is potable and meets treatment requirements. The treatment requirements are set out in Section 5 of the Drinking Water Protection Regulation (DWPR). They require that all surface water and ground water that are at risk of containing pathogens (i.e. "Groundwater Under the Direct Influence of Surface Water" - GUDI) to be disinfected. For small water systems, Section 3.1 of the DWPR requires the POE/POU treatment units used in these systems to make the water potable.

The Guidelines for Canadian Drinking Water Quality (Canadian Guidelines) will be used as a reference for potability. However, given the conditions of water systems within the Northern Health areas, it is sometimes necessary to apply the guidelines based on risk assessment of the individual cases. This paper focuses on meeting the microbiological guidelines for water supply systems, either by the POE/POU systems or by disinfection of the whole water systems.

(Note: The DWPR exempts small system from meeting the potability requirements if: "*each recipient of the water from the system has a POE/POU treatment system that make the water potable*". The implication of this clause in the DWPR and the process of approving small water systems with POE/POU systems are yet to be worked out. In this paper, it is assumed that these POE/POU units will need to meet the same potability standard as for treatment systems used for whole water systems). <500 people

Northern Health Drinking Water Treatment Objectives

This paper proposes treatment objectives that deal with the microbiological parameters: enteric viruses, pathogenic bacteria, Giardia cysts and Cryptosporidium oocysts. The general objectives being proposed are as follows:

4 log reduction or inactivation of viruses (using rotavirus as target)
3 log reduction or inactivation of Giardia and Cryptosporidium
2 refers to two treatment processes for surface water or GUDI systems
1 for less than 1 NTU of turbidity
0 E. Coli and Total Coliforms

These drinking water treatment objectives provide a minimum performance target for water suppliers to treat water to produce microbiologically safe drinking water. Depending on specific site situations, actual amount of treatment required would depend on the risks identified. It should also be remembered that water treatment is only one part of the multi-barrier approach in providing safe drinking water. For dealing with microbiological risks, properly locating and protecting the water sources are essential complementary steps to providing treatment.

4-log inactivation of viruses

Enteric viruses are easily inactivated by the use of chlorine. The cost of installing chlorination system is low and the operation is straightforward. In any case, chlorination of water systems is always recommended as a means to provide additional safeguards to the water system and to reduce the risk of regrowth in the distribution systems. However, some northern small communities and recreational facilities are reluctant to use chlorine, other methods to control viruses are desirable. Ultra Violet (UV) systems may be used but the effectiveness of UV varies significantly for different types of viruses. For example, the required UV dose for 4-log reduction of adenovirus is 226 mJ/cm^2, 56 mJ/cm^2 for rotavirus and 39 mJ/cm^2 for HAV. Since commercially available UV units are certified for 40 mJ/cm^2, it is important to understand the limitation of the equipment used.

The Canadian Guideline is as follows: *Treatment technologies and watershed or wellhead protection measures known to reduce the risk of waterborne outbreaks should be implemented and maintained if source water is subject to faecal contamination or if enteric viruses have been responsible for past waterborne outbreaks. Where treatment is required, treatment technologies should achieve at least a 4-log reduction and/or inactivation of viruses.*

It is recommended that 4-log reduction of viruses be required for all water systems that have a risk of enteric viruses in the water source. This risk is most likely to be present in surface water or GUDI but may also be present in secure ground water. In addition, a residual chlorine level should be maintained if the water system has an extensive distribution system or storage facility. Conversely, where the risk of enteric viruses is absent or low, as in the case of a remote recreational site with fully protected water source, the requirement may be relaxed, especially if other forms of treatment is in place.

The target virus should be rotavirus when considering the treatment objectives.

3-log inactivation of Giardia and Cryptosporidium

Giardia may be inactivated by large doses of free chlorine, ozone or chlorine dioxide. Filtration can be effective in removing Giardia cysts and Cryptosporidium oocysts but the performance is significantly dependant on the methods of filtration and operation. UV disinfection has been found to be highly effective for inactivating both parasites.

Commercially available systems with a certified dose rate of 40 mJ/cm^2 can achieve the 3-log inactivation required.

The USEPA uses a "bin system" to determine the level of treatment needed. In such case, the water source is monitored for Cryptosporidium or E. Coli for two years; the level of Cryptosporidium or E. Coli detected is then used to determine the log reduction required. The Canadian Guidelines have not included this approach in assessing risk.

The Canadian Guideline is as follows: *If the presence of viable, human-infectious cysts or oocysts is known or suspected in source waters, or if Giardia or Cryptosporidium has been responsible for past waterborne outbreaks in a community, a treatment and distribution regime and a watershed or wellhead protection plan (where feasible) or other measures known to reduce the risk of illness should be implemented. Treatment technologies in place should achieve at least a 3-log reduction in and/or inactivation of cysts and oocysts, unless source water quality requires a greater log reduction and/or inactivation.* In addition, the Guideline states that: *Because Giardia and Cryptosporidium are ubiquitous in surface waters in Canada and are more resistant to disinfection than most other infectious organisms, it is desirable that treatment known to achieve at least a 99.9% reduction of Giardia and Cryptosporidium be in place.*

It is recommended the 3-log reduction of Giardia and Cryptosporidium be required for systems that have a water source that is considered to have low risk of the parasites and have not had an outbreak of the disease. In general, surface water or GUDI would need to meet the minimum requirement but secure ground water would not. A higher level of reduction may be required if the situation justifies it, as in the cases of known outbreaks or identified risks.

2 methods of treatment (dual treatment)

Some of the microbiological agents of concern are more resistant to some forms of treatment than others. To provide the best protection, the Canadian Guidelines recommend that filtration and one form of disinfection be used in order to meet the treatment objectives; alternatively, two forms of disinfection (for example, chlorination and UV disinfection) may be used if the source water has low turbidity and low levels of E. Coli.

It is recommended that dual treatment be generally required for all surface water or GUDI but not a secure ground water source. Where the risk of enteric viruses in the water system is low, exceptions may be considered for POE/POU treatment systems or single connection commercial facilities. A phased implementation program over an agreed time frame to arrive at dual treatment should be considered with due consideration given to dealing with the pathogens of higher risk first.

1NTU or less in turbidity

Turbidity has been found to have correlations to health impacts. It also directly affects the effectiveness of water treatment processes. In general, turbidity is caused by particles in water and can be effectively reduced by filtration. Depending on filtration

technologies, filtered water could have turbidity ranges from 0.1 to 1.0 NTU. The Canadian Guideline on turbidity applies to filtered surface water or GUDI and is broken down by type of technology: chemically-assisted filtration, slow sand or diatomaceous earth filtration, and, membrane filtration. In order to comply with the Canadian Guideline, continuous monitoring of turbidity is required.

It is recommended that turbidity of treated water from a protected ground water source should be around 1 NTU. For treated surface water or GUDI, the turbidity levels should follow the Canadian Guideline on turbidity (expected turbidity reduction is dependant on method of filtration). Continuous monitoring of turbidity should be required for water systems (other than small water systems) with filtration in order to check for compliance.

0 E. Coli and Total Coliforms

E. Coli and Coliforms are easily controlled with chlorine or UV light and can be reduced by filtration. The DWPR calls for water suppliers to provide water with non-detectable E. Coli and Total Coliform based on sampling frequency established by the drinking water officers.

It is recommended that the treatment target for all water system be zero detection of E. Coli and Total Coliform based on sampling frequency established by the Drinking Water Leaders. Drinking water officers will take immediate follow up action when the limit is exceeded, in accordance to the appropriate policies, PHP 410 and 420.

Prepared by:
Michael Wu, P.Eng.
Regional Public Health Engineer

Date: March 2, 2006

Site C Camps
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APPENDIX C

Guidelines for Canadian Drinking Water Quality Summary Table

1076.0057.01 / May 24, 2012

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Guidelines for Canadian Drinking Water Quality

Summary Table

Prepared by the

Federal-Provincial-Territorial Committee on Drinking Water
of the
Federal-Provincial-Territorial Committee on Health and the Environment

December 2010

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Introduction

The *Guidelines for Canadian Drinking Water Quality* are published by Health Canada on behalf of the Federal-Provincial-Territorial Committee on Drinking Water (CDW). This summary table is updated regularly and published on Health Canada's website (www.healthcanada.gc.ca/waterquality). It supersedes all previous versions, as well as the published booklet of the *Sixth Edition of the Guidelines for Canadian Drinking Water Quality.*

These guidelines are based on current, published scientific research related to health effects, aesthetic effects, and operational considerations. Health-based guidelines are established on the basis of comprehensive review of the known health effects associated with each contaminant, on exposure levels and on the availability of treatment and analytical technologies. Aesthetic effects (e.g., taste, odour) are taken into account when these play a role in determining whether consumers will consider the water drinkable. Operational considerations are factored in when the presence of a substance may interfere with or impair a treatment process or technology (e.g., turbidity interfering with chlorination or UV disinfection) or adversely affect drinking water infrastructure (e.g., corrosion of pipes).

The Federal-Provincial-Territorial Committee on Drinking Water establishes the Guidelines for Canadian Drinking Water Quality specifically for contaminants that meet all of the following criteria:

1. exposure to the contaminant could lead to adverse health effects;
2. the contaminant is frequently detected or could be expected to be found in a large number of drinking water supplies throughout Canada; and
3. the contaminant is detected, or could be expected to be detected, at a level that is of possible health significance.

If a contaminant of interest does not meet all these criteria, the Federal-Provincial-Territorial Committee on Drinking Water may choose not to establish a numerical guideline or develop a Guideline Technical Document. In that case, a Guidance Document may be developed.

Guidance Documents undergo a process similar to Guideline Technical Documents, including public consultations through the Health Canada website. They are offered as information for drinking water authorities, and help provide guidance relating to contaminants, drinking water management issues or emergency situations. Consultation documents, Guideline Technical Documents and Guidance documents are available from the Health Canada website (www.healthcanada.gc.ca/waterquality).

In general, the highest priority guidelines are those dealing with microbiological contaminants, such as bacteria, protozoa and viruses. Any measure taken to reduce concentrations of chemical contaminants should not compromise the effectiveness of disinfection.

Inquiries can be directed to: water_eau@hc-sc.gc.ca

Membership of the Federal-Provincial-Territorial Committee on Drinking Water

Jurisdictional representatives

Alberta	Department of Environment	Dr. Donald Reid
British Columbia	Ministry of Health Services	Mr. Barry Boettger
Manitoba	Department of Water Conservation	Ms. Kim Philip
New Brunswick	Department of Health and Wellness	Ms. Karen White
Newfoundland and Labrador	Department of Environment and Conservation	Mr. Haseen Khan
Northwest Territories	Stanton Territorial Health Authority	Mr. Duane Fleming
Nova Scotia	Department of Environment and Labour	Ms. Judy MacDonald
Nunavut Territory	Department of Health and Social Services	Mr. Peter Workman
Ontario	Ministry of the Environment	Dr. Satish Deshpande
Prince Edward Island	Department of Environment, Energy and Forestry	Mr. George Somers
Québec	Ministère du Développement durable, de l'Environnement et des Parcs	Ms. Caroline Robert
Saskatchewan	Department of the Environment	Mr. Sam Ferris
Yukon Territory	Department of Health and Social Services	Ms. Patricia Brooks
Canada	Department of Health	Dr. John Cooper

Liaison officers

Federal-Provincial-Territorial Committee on Health and the Environment (CHE)	Mr. Peter Workman
Environment Canada/Canadian Council of Ministers of the Environment	Dr. Doug Spry

Committee secretary

Health Canada (Water, Air and Climate Change Bureau, Safe Environments Directorate, Healthy Environments and Consumer Safety Branch)	Ms. Anne Vézina

New, revised, reaffirmed and upcoming guidelines

Guidelines for several chemical, physical and microbiological parameters are new or have been revised since the publication of the *Sixth Edition of the Guidelines for Canadian Drinking Water Quality* in 1996. These new and revised guidelines are presented in Table 1.

Table 1. New and revised guidelines

Parameter	Guideline (mg/L)	Previous guideline (mg/L)	CHE approval
Microbiological parameters[a]			
Bacteriological		0 coliforms/100 mL	
E.coli	0 per 100 mL		2006
Total coliforms	0 per 100 mL		2006
Heterotrophic plate count	No numerical guideline required		2006
Emerging pathogens	No numerical guideline required		2006
Protozoa	No numerical guideline required	None	2004
Enteric viruses	No numerical guideline required	None	2004
Turbidity	0.3/1.0/0.1 NTU[b]	1.0 NTU	2004
Chemical and physical parameters			
Aluminum	0.1/0.2[c]	None	1999
Antimony	0.006	None	1997
Arsenic	0.01	0.025	2006
Benzene	0.005	0.005	2009
Bromate	0.01	None	1999
Chlorate	1	None	2008
Chlorine	No numerical guideline required	None	2009
Chlorite	1	None	2008
Cyanobacterial toxins—microcystin-LR	0.0015	None	2002
Fluoride	1.5	1.5	1996
Formaldehyde	No numerical guideline required	None	1998
Haloacetic Acids—Total (HAAs)	0.08	None	2008
2-Methyl-4-chlorophenoxyacetic acid (MCPA)	0.1	None	2010
Methyl *tertiary*-butyl ether (MTBE)	0.015	None	2006
Trichloroethylene (TCE)	0.005	0.05	2005
Trihalomethanes—Total (THMs)[d]	0.1	0.1	2006

Parameter	Guideline (mg/L)	Previous guideline (mg/L)	CHE approval
Uranium	0.02	0.1	2000
Radiological parameters			
Cesium-137 (^{137}Cs)	10 Bq/L	10 Bq/L	2009
Iodine-131 (^{131}I)	6 Bq/L	6 Bq/L	2009
Lead-210 (^{210}Pb)	0.2 Bq/L	0.1 Bq/L	2009
Radium-226 (^{226}Ra)	0.5 Bq/L	0.6 Bq/L	2009
Strontium-90 (^{90}Sr)	5 Bq/L	5 Bq/L	2009
Tritium (^{3}H)	7000 Bq/L	7000 Bq/L	2009

[a]Refer to section on Guidelines for microbiological parameters.
[b]Based on conventional treatment/slow sand or diatomaceous earth filtration/membrane filtration.
[c]This is an operational guidance value, designed to apply only to drinking water treatment plants using aluminum-based coagulants. The operational guidance values of 0.1 mg/L applies to conventional treatment plants, and 0.2 mg/L applies to other types of treatment systems.
[d]The separate guideline for BDCM was rescinded based on new science. See addendum to the THM document.

In certain situations, the Federal-Provincial-Territorial Committee on Drinking Water may choose to develop guidance documents: for contaminants that do not meet the criteria for guideline development, and for specific issues for which operational or management guidance is warranted.

Table 2. Guidance documents

Parameter or issue	CHE approval
Boil water advisories	2009
Chloral hydrate	2008
Corrosion Control	2009
Drinking water avoidance advisories	2009
Potassium from water softeners	2008

The Federal-Provincial-Territorial Committee on Drinking Water has established a science-based process to systematically review older guidelines to assess the need to update them. Table 3 provides the list of parameters whose guidelines remain appropriate and have been reaffirmed as a result of this review. Health Canada and the FPT Committee on Drinking Water will continue to monitor research on these parameters and recommend any revision(s) to the guidelines that is deemed necessary.

Table 3. Reaffirmed guidelines (2005)

Asbestos	Chloride	Diuron	Odour	2,3,4,6-Tetrachlorophenol
Azinphos-methyl	Colour	Ethylbenzene	Paraquat	Toluene
Bendiocarb	Cyanazine	Gasoline	Pentachlorophenol	2,4,6-Trichlorophenol
Benzo(a)pyrene	Diazinon	Glyphosate	Phorate	Trifluralin
Bromoxynil	Dicamba	Iron	Picloram	Xylenes
Cadmium	2,4-Dichlorophenol	Magnesium	Silver	Zinc
Calcium	Diclofop-methyl	Malathion	Taste	
Carbaryl	Dimethoate	Methoxychlor	Temperature	
Carbofuran	Diquat	Metribuzin	Terbufos	

Table 4 outlines documents which are being or have been developed and are awaiting approval through the Federal-Provincial-Territorial process.

Table 4. Upcoming documents (not yet finalized/approved)

Parameter or subject	Document type (GTD or guidance)	Current status
Ammonia	GTD	In preparation[b]
Carbon tetrachloride	GTD	In preparation[a]
Chromium	GTD	In preparation[b]
Dichloroethane, 1,2-	GTD	In preparation[b]
Dichloromethane	GTD	In preparation[a]
E.coli	GTD	In preparation[b]
Enteric viruses	GTD	In preparation[a]
Fluoride	GTD	In preparation[a]
Heterotrophic plate count	guidance	In preparation[b]
Nitrate/Nitrite	GTD	In preparation[b]
N-Nitrosodimethylamine (NDMA)	GTD	In preparation[a]
Protozoa	GTD	In preparation[b]
Selenium	GTD	In preparation[b]
Tetrachloroethylene	GTD	In preparation[b]
Total coliforms	GTD	In preparation[b]
Turbidity	GTD	In preparation[b]
Vinyl chloride	GTD	In preparation[b]

[a]Final guideline technical document or guidance document in preparation for final approval/posting.
[b]Guideline technical document or guidance document being prepared for public consultation.

Guidelines for microbiological parameters

Currently available detection methods do not allow for the routine analysis of all microorganisms that could be present in inadequately treated drinking water. Instead, microbiological quality is determined by testing drinking water for *Escherichia coli*, a bacterium that is always present in the intestines of humans and other animals and whose presence in drinking water would indicate faecal contamination of the water.

Bacteriological guidelines

Escherichia coli

The maximum acceptable concentration (MAC) of *Escherichia coli* in public, semi-public, and private drinking water systems is none detectable per 100 mL.

Testing for *E. coli* should be carried out in all drinking water systems. The number, frequency, and location of samples for *E. coli* testing will vary according to the type and size of the system and jurisdictional requirements.

Total coliforms

The MAC of total coliforms in water leaving a treatment plant in a public system and throughout semi-public and private supply systems is none detectable per 100 mL.

For distribution systems in public supplies where fewer than 10 samples are collected in a given sampling period, no sample should contain total coliform bacteria. In distribution systems where greater than 10 samples are collected in a given sampling period, no consecutive samples from the same site or not more than 10% of samples should show the presence of total coliform bacteria.

Testing for total coliforms should be carried out in all drinking water systems. The number, frequency, and location of samples for total coliform testing will vary according to the type and size of the system and jurisdictional requirements.

Heterotrophic plate count

No MAC is specified for heterotrophic plate count (HPC) bacteria in water supplied by public, semi-public, or private drinking water systems. Instead, increases in HPC concentrations above baseline levels are considered undesirable.

Emerging pathogens

No MAC for current or emerging bacterial waterborne pathogens has been established. Current bacterial waterborne pathogens include those that have been previously linked to gastrointestinal illness in human populations. Emerging bacterial waterborne pathogens include, but are not limited to, *Legionella*, *Mycobacterium avium* complex, *Aeromonas hydrophila*, and *Helicobacter pylori*.

Protozoa

Although *Giardia* and *Cryptosporidium* can be responsible for severe and, in some cases, fatal gastrointestinal illness, it is not possible to establish MACs for these protozoa in drinking water at this time. Routine methods available for the detection of cysts and oocysts suffer from low recovery rates and do not provide any information on their viability or human infectivity. Nevertheless, until better monitoring data and information on the viability and infectivity of cysts and oocysts present in drinking water are available, measures should be implemented to reduce the risk of illness as much as possible. If the presence of viable, human-infectious cysts or oocysts is known or suspected in source waters, or if

Giardia or *Cryptosporidium* has been responsible for past waterborne outbreaks in a community, a treatment and distribution regime and a watershed or wellhead protection plan (where feasible) or other measures known to reduce the risk of illness should be implemented. Treatment technologies in place should achieve at least a 3-log reduction in and/or inactivation of cysts and oocysts, unless source water quality requires a greater log reduction and/or inactivation.

Viruses

Although enteric viruses can be responsible for severe and, in some cases, fatal illnesses, it is not possible to establish MACs for enteric viruses in drinking water at this time. Treatment technologies and watershed or wellhead protection measures known to reduce the risk of waterborne outbreaks should be implemented and maintained if source water is subject to faecal contamination or if enteric viruses have been responsible for past waterborne outbreaks. Where treatment is required, treatment technologies should achieve at least a 4-log reduction and/or inactivation of viruses.

Turbidity

Waterworks systems that use a surface water source or a groundwater source under the direct influence of surface water should filter the source water to meet the following health-based turbidity limits, as defined for specific treatment technologies. Where possible, filtration systems should be designed and operated to reduce turbidity levels as low as possible, with a treated water turbidity target of less than 0.1 NTU at all times. Where this is not achievable, the treated water turbidity levels from individual filters:

1. For **chemically assisted filtration**, shall be less than or equal to **0.3 NTU** in at least 95% of the measurements made, or at least 95% of the time each calendar month, and shall not exceed 1.0 NTU at any time.
2. For **slow sand or diatomaceous earth filtration**, shall be less than or equal to **1.0 NTU** in at least 95% of the measurements made, or at least 95% of the time each calendar month, and shall not exceed 3.0 NTU at any time.
3. For **membrane filtration**, shall be less than or equal to **0.1 NTU** in at least 99% of the measurements made, or at least 99% of the time each calendar month, and shall not exceed 0.3 NTU at any time. If membrane filtration is the sole treatment technology employed, some form of virus inactivation[*] should follow the filtration process.

Guidelines for chemical and physical parameters

Table 5 provides the complete list of all current numerical Guidelines for chemical and physical parameters. Guidelines are either health-based and listed as Maximum Acceptable Concentrations (MAC), based on aesthetic considerations and listed as aesthetic objectives (AO) or established based on operational considerations and listed as Operational Guidance Values (OG). Parameters for which the health-based guideline was developed as an interim maximum acceptable concentration (IMAC) are identified with an asterisk (*) in the table below. The use of these 'interim' MACs was discontinued by the Federal-Provincial-Territorial Committee on Drinking Water in 2003. For more information on specific guidelines, please refer to the guideline technical document for the parameter of concern.

[*]Some form of virus inactivation is required for all technologies. The difference is that chemically assisted, slow sand and diatomaceous earth filters are credited with log virus reductions and membrane filters receive no credit.

Table 5. Health-based and aesthetic guidelines for chemical/physical parameters

Parameter	MAC (mg/L)	AO [or OG] (mg/L)	Year of approval (or reaffirmation)
Aldicarb	0.009		1994
Aldrin + dieldrin	0.0007		1994
Aluminum[a]		[0.1/0.2]	1998
*Antimony[b]	0.006		1997
Arsenic	0.01		2006
*Atrazine + metabolites	0.005		1993
Azinphos-methyl	0.02		1989 (2005)
Barium	1		1990
Bendiocarb	0.04		1990 (2005)
Benzene	0.005		2009
Benzo[a]pyrene	0.00001		1988 (2005)
*Boron	5		1990
*Bromate	0.01		1998
*Bromoxynil	0.005		1989 (2005)
Cadmium	0.005		1986 (2005)
Carbaryl	0.09		1991 (2005)
Carbofuran	0.09		1991 (2005)
Carbon tetrachloride	0.005		1986
Chloramines—total	3		1995
Chlorate	1		2008
Chloride		≤250	1979 (2005)
Chlorite	1		2008
Chlorpyrifos	0.09		1986
Chromium	0.05		1986
Colour[d]		≤15 TCU	1979 (2005)
Copper[b]		≤1.0	1992
*Cyanazine	0.01		1986 (2005)
Cyanide	0.2		1991
Cyanobacterial toxins–Microcystin-LR[c]	0.0015		2002
Diazinon	0.02		1986 (2005)
Dicamba	0.12		1987 (2005)
1,2-Dichlorobenzene[e]	0.2	≤0.003	1987
1,4-Dichlorobenzene[e]	0.005	≤0.001	1987
*1,2-Dichloroethane	0.005		1987

Parameter	MAC (mg/L)	AO [or OG] (mg/L)	Year of approval (or reaffirmation)
1,1-Dichloroethylene	0.014		1994
Dichloromethane	0.05		1987
2,4-Dichlorophenol,	0.9	≤0.0003	1987 (2005)
*2,4-Dichlorophenoxyacetic acid (2,4 -D)	0.1		1991
Diclofop-methyl	0.009		1987 (2005)
*Dimethoate	0.02		1986 (2005)
Dinoseb	0.01		1991
Diquat	0.07		1986 (2005)
Diuron	0.15		1987 (2005)
Ethylbenzene		≤0.0024	1986 (2005)
Fluoride	1.5		1996
*Glyphosate	0.28		1987 (2005)
Haloacetic Acids–Total (HAAs)	0.08		2008
Iron		≤0.3	1978 (2005)
Lead[b]	0.01		1992
Malathion	0.19		1986 (2005)
Manganese		≤0.05	1987
Mercury	0.001		1986
Methoxychlor	0.9		1986 (2005)
2-Methyl-4-chlorophenoxyacetic acid (MCPA)	0.1		2010
Methyl tertiary-butyl ether (MTBE)		0.015	2006
*Metolachlor	0.05		1986
Metribuzin	0.08		1986 (2005)
Monochlorobenzene	0.08	≤0.03	1987
Nitrate[f]	45		1987
Nitrilotriacetic acid (NTA)	0.4		1990
Odour		Inoffensive	1979 (2005)
*Paraquat (as dichloride)[g]	0.01		1986 (2005)
Parathion	0.05		1986
Pentachlorophenol	0.06	≤0.030	1987 (2005)
pH[h]		6.5–8.5	1995
Phorate	0.002		1986 (2005)
*Picloram	0.19		1988 (2005)
Selenium	0.01		1992
*Simazine	0.01		1986

Parameter	MAC (mg/L)	AO [or OG] (mg/L)	Year of approval (or reaffirmation)
Sodium[i]		≤200	1992
Sulphate[j]		≤500	1994
Sulphide (as H_2S)		≤0.05	1992
Taste		Inoffensive	1979 (2005)
Temperature		≤15°C	1979 (2005)
*Terbufos	0.001		1987 (2005)
Tetrachloroethylene	0.03		1995
2,3,4,6-Tetrachlorophenol	0.1	≤0.001	1987 (2005)
Toluene		≤0.024	1986 (2005)
Total dissolved solids (TDS)		≤500	1991
Trichloroethylene	0.005		2005
2,4,6-Trichlorophenol	0.005	≤0.002	1987 (2005)
*Trifluralin	0.045		1989 (2005)
Trihalomethanes-total (THMs)[k]	0.1		2006
Turbidity[l]			2004
*Uranium	0.02		1999
Vinyl chloride	0.002		1992
Xylenes—total		≤0.3	1986 (2005)
Zinc[b]		≤5.0	1979 (2005)

[a]This is an operational guidance value, designed to apply only to drinking water treatment plants using aluminum-based coagulants. The operational guidance values of 0.1 mg/L applies to conventional treatment plants, and 0.2 mg/L applies to other types of treatment systems.
[b]Faucets should be thoroughly flushed before water is taken for consumption or analysis.
[c]The guideline is considered protective of human health against exposure to all microcystins that may be present.
[d]TCU = true colour unit.
[e]In cases where total dichlorobenzenes are measured and concentrations exceed the most stringent value (0.005 mg/L), the concentrations of the individual isomers should be established.
[f]Equivalent to 10 mg/L as nitrate–nitrogen. Where nitrate and nitrite are determined separately, levels of nitrite should not exceed 3.2 mg/L.
[g]Equivalent to 0.007 mg/L for paraquat ion.
[h]No units.
[i]It is recommended that sodium be included in routine monitoring programmes, as levels may be of interest to authorities who wish to prescribe sodium-restricted diets for their patients.
[j]There may be a laxative effect in some individuals when sulphate levels exceed 500 mg/L.
[k]Expressed as a running annual average. The guideline is based on the risk associated with chloroform, the trihalomethane most often present and in greatest concentration in drinking water.
[l]Refer to section on Guidelines for microbiological parameters for information related to various treatment processes.

Parameters without guidelines

Some chemical and physical parameters for which a Guideline Technical Document is available have been identified as not requiring a numerical guideline, because currently available data indicate that it poses no health risk or aesthetic problem at the levels generally found in drinking water in Canada.

Table 6. Parameters without numerical guidelines

Ammonia	Asbestos
Calcium	Chlorine
Formaldehyde	Gasoline
Hardness[a]	Magnesium
Radon	Silver

[a]Public acceptance of hardness varies considerably. Generally, hardness levels between 80 and 100 mg/L (as $CaCO_3$) are considered acceptable; levels greater than 200 mg/L are considered poor but can be tolerated; those in excess of 500 mg/L are normally considered unacceptable. Where water is softened by sodium ion exchange, it is recommended that a separate, unsoftened supply be retained for culinary and drinking purposes.

Archived parameters

The Federal-Provincial-Territorial Committee on Drinking Water has established a science-based process to systematically review older guidelines and archive older guidelines which are no longer required. Guidelines are archived for parameters which are no longer found in Canadian drinking water supplies at levels that could pose a risk to human health, including pesticides which are no longer registered for use in Canada, and for mixtures of contaminants that are addressed individually. Table 7 provides the list of parameters whose guidelines have been archived as a result of this review.

Table 7. Parameters that have been archived[a]

Chlordane (total isomers)[b]	Polychlorinated biphenyls (PCBs)
Dichlorodiphenyltrichloroethane (DDT) + metabolites[b]	Polycyclic aromatic hydrocarbons (PAH)[c]
Endrin[b]	Resin acids
Heptachlor + heptachlor epoxide[b]	Tannin
Lignin[b]	Temephos[d]
Lindane[b]	Total organic carbon (TOC)
Methyl-parathion[b]	Toxaphene[b]
Mirex	Triallate[d]
Pesticides (total)	2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)[d]
Phenols (total)	2,4,5-Trichlorophenoxypropionic acid (2,4,5-TP)[b]
Phthalic acid esters (PAE)	

[a]Published in the 1978 version of the *Supporting Documentation* for these parameters (available upon request).
[b]In 1978 'Pesticides' Supporting Documentation.
[c]Other than benzo[a]pyrene.
[d]No documentation available.

Guidelines for radiological parameters

Natural sources of radiation are responsible for the large majority of radiation exposure (>98%), excluding medical exposure. Guidelines for radiological parameters focus on routine operational conditions of existing and new water supplies and does not apply in the event of contamination during an emergency involving a large release of radionuclides into the environment.They have been developed taking into account new studies and approaches, including dosimetric information released by the International Commission on Radiological Protection (ICRP) in 1996 (ICRP, 1996). Maximum acceptable concentrations (MACs) in drinking water have been established for the natural and artificial radionuclides that are most commonly detected in Canadian water supplies, using internationally accepted equations and principles and based solely on health considerations. They are calculated using a reference dose level of 0.1 mSv for 1 year's consumption of drinking water, assuming a consumption of 2 L/day at the MAC.

To facilitate the monitoring of radionuclides in drinking water, the reference level of dose is expressed as an activity concentration, which can be derived for each radionuclide from published radiological data. The National Radiological Protection Board has calculated dose conversion factors (DCFs) for radionuclides based on metabolic and dosimetric models for adults and children. Each DCF provides an estimate of the 50-year committed effective dose resulting from a single intake of 1 Bq[†] of a given radionuclide.

The MACs of radionuclides in public water supplies are derived from adult DCFs, assuming a daily water intake of 2 L, or 730 L/year, and a maximum committed effective dose of 0.1 mSv, or 10% of the International Commission on Radiological Protection limit on public exposure:

$$\text{MAC (Bq/L)} = \frac{1 \times 10^{-4}\ \text{(Sv/year)}}{730\ \text{(L/year)} \times \text{DCF (Sv/Bq)}}$$

The radiological effects of two or more radionuclides in the same drinking water source are assumed to be additive. Thus, the following summation formula should be satisfied in order to demonstrate compliance with the guidelines:

$$\sum_i \frac{C_i}{MAC_i} \leq 1$$

where C_i and MAC_i are the observed and maximum acceptable concentrations, respectively, for each contributing radionuclide. Only those radionuclides that are detected with at least 95% confidence should be included in the summation. Detection limits of undetected radionuclides should not be substituted for the concentrations C_i. Otherwise, a situation could arise where a sample fails the summation criterion even though no radionuclides are present.

Water samples may be initially analysed for the presence of radioactivity using techniques for gross alpha and gross beta determinations rather than measurements of individual radionuclides. Compliance with the guidelines may be inferred if the measurements are less than 0.5 Bq/L for gross alpha

[†]Becquerel (Bq) is the unit of activity of a radioactive substance, or the rate at which transformations occur in the substance. One becquerel is equal to one transformation per second and approximately equal to 27 picocuries (pCi).

activity and less than 1 Bq/L for gross beta activity. Alpha emissions are generally associated with naturally occurring radionuclides, whereas beta emissions are generally associated with artificial radionuclides. Although facilitating routine examination of large numbers of samples, these procedures do not allow for confirmation of the identities of the contributing radionuclides. These measurements are generally suitable either as a preliminary screening procedure to determine if further radioisotope-specific analysis is necessary or, if radionuclide analyses have been carried out previously, for detecting changes in the radiological characteristics of the drinking water source. The sampling and analyses for individual radionuclides should be carried out often enough to accurately characterize the annual exposure. If the source of the radioactivity is known or expected to be changing rapidly with time, then the sampling frequency should reflect this factor. If there is no reason to expect concentrations to vary with time, then sampling may be carried out seasonally, semi-annually or annually. If measured concentrations are consistent and well below the MACs, this would be an argument for reducing the sampling frequency. In contrast, the sampling frequency should be maintained, or even increased, if concentrations are approaching individual MACs or if the sum of ratios of the observed concentration to the MAC for each contributing radionuclide approaches 1.

Table 8. Health based guidelines for radiological parameters

Radiological parameters	
Cesium-137 (^{137}Cs)	10 Bq/L
Iodine-131 (^{131}I)	6 Bq/L
Lead-210 (^{210}Pb)	0.2 Bq/L
Radium-226 (^{226}Ra)	0.5 Bq/L
Strontium-90 (^{90}Sr)	5 Bq/L
Tritium (^{3}H)	7000 Bq/L

Site C Camps
Water & Sewer
Feasibility Study

Report

FINAL -
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Appendix D

Design Information provided by BC Hydro

1076.0057.01 / May 24,
2012

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URBANSYSTEMS.

SITE C CLEAN ENERGY PROJECT

CONFIDENTIAL

From: Erin Harlos, Mike Pauletto, Yubin Wang, and Site C team contributors.
To: Kristin Bayet, Urban Systems Team.
Version: REVISION 1: for Update
Date: January 19, 2012
Subject: Response to Urban Systems Questions re: Servicing Requirements Feasibility Assessment

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General comments in responding to the questions:

1. The Workers Accommodation and Services would be a Design-Build-Operate performance contract to be carried out by a specialized camp and service provider. The DBM (Design Basis Memorandum) was intended to provide a starting document for the engineering, environment assessment, social economic studies, procurement, project management, and coordination with the City of Fort St. John. It is also intended to collect inputs and feedbacks from these parties.

2. The Mobilization Construction Manuals on water supply and sewage treatment by US Army Corps of Engineers (USACE) were adopted as the basis to provide quantity estimates in the DBM. This was in consideration that the two camps proposed for the project would be temporary construction facilities in northern rural areas. We understand that the numbers in those USACE manuals are on the conservative side compared to municipal standards; however, we assume that in general the information obtained would be good for planning purposes at this stage.

3. It's great to have quantity estimates for water and sewage using municipal design standard for comparison. In addition, review of the DBM by local authority to check conformity with local bylaws and regulations are required; for example, fire protection flow requirements, etc.

4. Camp population is a key factor for estimating water and sewage quantities. In the DBM, it was based on the assumption that there would be a 500men North Camp and 1500men South Camp. As the peak onsite camp requirements at south site was re-estimated to be 1200, there would be 350 non-resident of the camp works at site but living in town or RV parks at site). According to USACE manual, non-resident would also count 1/3 of the water requirements and sewage contribution. An adjusted calculation has been prepared to account for this. We understand that we may need to review the assumptions on camp population according to available results from local labour market studies.

Questions- Sanitary Sewer: (Mike and Yubin)

1. Design Flows – What assumptions were used to calculate the design flows provided? US Army Corps (see files attached)

a. What is the estimated average daily sewer production per person (litres per capita per day) - 650 Lpcd? (Note: Municipal average for FSJ is 300.)

US Army Corps standard (EM 1110-3-172, Page No. 4-1) was used as the primary basis for the quantity estimate; however, in the old calculation, it also referenced to the City of St. John "Liquid Waste Management Plan" at http://www.fortstjohn.ca/files/stage%203%20report.pdf

We are assuming 100 Gallon/day/capita (379litre/day/capita) based on the US Army Corps standard (EM 1110-3-172, Page No. 4-1). Please note the design population is to be adjusted by a capacity factor 1.5 according to the Army standard (see Page No. 3-1). With the capacity factor, it makes 568litre/day/capita; therefore, we are on the conservative side if compared to the municipal standard.

Please note that for the South Camp, we did a new adjusted calculation to account for the contribution of the 350 no-residents. The calculation can be adjusted once the camp population are confirmed.

Please refer to the table of calculations below under c.

b. Why is the average flow higher in the summer? – peak factor for max month of 1.7 was used.

Future consideration of: CFSJ Subdivision Servicing Bylaw. Removed reference to City of St. John "Liquid Waste Management Plan", Urban Systems

The calculation was adjusted using USACE Manual EM 1110-3-1720.

In the adjusted calculation, design population was adjusted using the allowance of hydraulic loading per resident (see Page No. 4-1 of EM 1110-3-1720) and capacity factor (see Page No. 4-2 of EM 1110-3-1720).

Please refer to the table of calculations below under c.

c. How was the max day peak factor of 3.2 chosen?

Does this represent the peak hourly flow during the day? Yes

Future consideration of: CFSJ Subdivision Servicing Bylaw. Removed reference to City of St. John "Liquid Waste Management Plan", Urban Systems

In the adjusted calculation, assumptions in USACE manual EM 1110-3-1720 are used: the treatment plant would be designed using the average hydraulic loading; whereas the sewage conduits and pipings would be designed using an expected peak rate of flow of 3 times the average loading. Please refer to Page No. 4-2, item 4-4 a.

The updated calculations are as follows:

North Bank Camp Waste Water Quantity Estimate
according to US Army Corps of Engineers Manual EM 1110-3-172

No.	Item Description	Quantity	Unit
1	Camp Resident Population	500	person
	Non-Resident Population	-	person
	Estimated Population	500	person
	Capacity Factor	1.5	
	Design Population	750	person
1	Per Capita Sewage Hydraulic Loading	100	gal/person/day
		379	litre/person/day
3	**Daily Hydraulic Loading**	**280**	**m3/day**
4	Peak Flow (for collecting and distribution system design)		
	day peak factor	3.0	
	Peak Flow	**840**	**m3/day**

South Bank Camp Waste Water Quantity Estimate
according to US Army Corps of Engineers Manual EM 1110-3-172

No.	Item Description	Quantity	Unit
1	Camp Resident Population	1,200	person
	Non-Resident Population*	350	person
	Estimated Population	1,317	person
	Capacity Factor	1.5	
	Design Population	1,975	person
1	Per Capita Sewage Hydraulic Loading	100	gal/person/day
		379	litre/person/day
3	**Daily Hydraulic Loading**	**750**	**m3/day**
4	Peak Flow (for collecting and distribution system design)		
	day peak factor	3.0	
	Peak Flow	**2,250**	**m3/day**

* According to USACE manual, non-resident would also count 1/3 of the water requirements and sewage contribution. An adjusted calculation has been prepared to account for this.

Questions – Water: (Yubin / Mike)

1. Design Flows:

a. How was the Total Water Required for Worker Housing Population (Housing Demand) calculated? Is this an average flow, max day flow or a peak hour flow? What does the capacity factor of 1.5 represent?

We are assuming 150Gallon/day/capita (567litre/day/capita) according to US Army Corps standard (EM 1110-3-160, Page No. 2-1). Please note the design population is to be adjusted by a capacity factor 1.5 according to the Army standard (see Page No. 3-1). With the capacity factor, it makes 852litre/day/capita; therefore, we are on the conservative side if compared to the municipal standard.

Please note that for the South Camp, we did a new adjusted calculation to account for the contribution of the 350 no-residents. The calculation can be adjusted once the camp population are confirmed.

Please refer to the table of calculations after "3" below.

2. Fire Flows: (Yubin / Mike)

a) How was the Fire Fighting Requirement developed? US Army Corps (See Water Supply – 3-1)

a. What fire flow is required at the camp? Will either water system provide fire protection (or domestic water) for areas other than the camps (i.e. dam construction site)?

Use of a surge tank of potable water with upper limit for drinking and retaining reservoir for fire.

Fire protection flows at camp site are only for the Worker Accommodation. A Fire chief and crews has been planned for dam site construction areas and water will be managed separately.

Fire flow quantity was a ball park number based on Yubin's previous project experience; it needs to be confirmed by a mechanical engineer (on fire-fighting design and also subject to local authority approval

3. Reservoir Size: (Yubin / Mike)

a. The memo indicates that the reservoir sizes for the two camps are based on the 2 hour fire storage requirements and 50% of the Housing Demand. The values in the tables don't appear to match this calculation. Please confirm the storage volume requirements.

The calculation assumptions are as per USACE manual; refer to EM 1110-3-160, Page No. 1-2

However, fire protection flow quantity was a ball park number based on Yubin's previous project experience; it needs to be confirmed by a mechanical engineer (on fire-fighting design and also subject to local authority approval

North Bank Camp Domestic Water Quantity Estimate

according to US Army Corps of Engineers Manual EM 1110-3-160

No.	Item Description	Quantity	Unit
1	Camp Resident Population	500	person
	Non-Resident Population	-	person
	Effective Population	500	person
	Capacity Factor	1.5	
	Design Population	**750**	**person**
2	Water requirements per person	150	gal/person/day
		568	litre/person/day
3	**Total Water Required for Workers**	**425,813**	**litre/day**
		430	**m3/day**
4	Fire-fighting flow (to be confirmed)	500	gal/min
		113,550	litre/hr
	Fire-fighting Requirements (2hrs)	**227,100**	**litre/day**
		227	**m3/day**
5	**Total Water Required Per Day**	**660**	**m3/day**
6	Peak Domestic Demand (the greater of a&b)		
	(a). Max. day demand (2.5 of "3" above)	1,075	m3/day
	(b). Fire flow plus 50% reqd.	440	m3/day
	Peak Demand	**1,075**	**m3/day**
7	Water source - well	150	gal/min/each
	(to be confirmed)	34,065	litre/hr/each
8	No of wells required - calculated	1.3	
	Wells to be drilled (to be confirmed)	**2**	**to confirm**
9	Reservoir Size	440,000	litre
		440	**m3**

Note: fire-fighting requirements need to be confirmed

South Bank Camp Domestic Water Quantity Estimate

according to US Army Corps of Engineers Manual EM 1110-3-160

No.	Item Description	Quantity	Unit
1	Camp Resident Population	1,200	person
	Non-Resident Population*	350	person
	Effective Population	1,317	person
	Capacity Factor	1.5	
	Design Population	**1,975**	**person**
2	Water requirements per person	150	gal/person/day

		568	litre/person/day
3	**Total Water Required for Workers**	**1,121,306**	**litre/day**
		1,120	**m3/day**
4	Fire-fighting flow (to be confirmed)	500	gal/min
		113,550	litre/hr
	Fire-fighting Requirements (2hrs)	**227,100**	**litre/day**
		227	**m3/day**
5	**Total Water Required Per Day**	**1,350**	**m3/day**
6	Peak Domestic Demand (the greater of a&b)		
	(a). Max. day demand (2.5 of "3" above)	2,800	m3/day
	(b). Fire flow plus 50% reqd.	790	m3/day
	Peak Demand (the greater of a&b)	**2,800**	**m3/day**
7	Water source - well	150	gal/min
	(to be confirmed)	34,065	litre/hr
8	No of wells required - calculated	3.4	
	Wells to be drilled (to be confirmed)	**4**	**to confirm**
9	Reservoir Size	788,000	litre
		788	**m3**

Note: fire-fighting requirements need to be confirmed

* According to USACE manual, non-resident would also count 1/3 of the water requirements and sewage contribution. An adjusted calculation has been prepared to account for this.

4. Water Source:

a. How were the water source flows of 150 gal/min determined? (Yubin / Mike)

Request that Urban systems update based on their experience in region.

b. What are current and future low and high water levels for the Peace River near the camps? (Amy Price-Phillips – BCH)

We have a hydraulic model that estimates water levels throughout the river under existing conditions and for the various phases of construction. We are in the process of finalizing a memo that summarizes the effect of the project on water levels upstream and downstream of the construction site. This may be useful for Urban Systems' study.

The water levels in the area, from 2000 to 2009, the range of hourly simulated water levels just downstream of the dam axis (approximate chainage 106.5 km, i.e. 106.5 km downstream of Bennett Dam) is roughly 409 m to 412.5 m. During Stage 1 (channelization) and Stage 2 (diversion) the range of water levels at this location is expected to be similar.

A further discussion can be held directly with Amy and Urban Systems to discuss in more details.

c. Is there any recent water quality data available for the Peace River near the camp locations? (Bruce Mattock – BCH)

Yes Golder sampling in 2007 and 2008, reports on website, more sampling 2010 and 2011 by Golder in draft.

http://www.bchydro.com/energy_in_bc/projects/site_c/document_centre/stage_2_reports.html

Baseline Data Collection – Peace River Watershed Water Quality and Dinosaur Lake Limnology Sampling – 2008 [PDF, 8.2 Mb]. Golder Associates Ltd. 2009.

Baseline Data Collection – Water Quality, River Sediment, Soil, and Vegetation Samples from the Peace River Watershed – 2007 [PDF, 11.3 Mb]. Golder Associates Ltd. 2009.

d. Is there any recent groundwater water quality data available in the vicinity of the two proposed camps? (Kyle Robertson and Duane Anderson, BCH)

Materials provided to Urban Systems

Note: the water tested within the adits may be affected by shotcrete, steel rebar, etc and other materials and processes associated with the adit structures and that this data may not be representative of typical groundwater.

e. Will dam construction affect the quality of the river water downstream during construction? (Bruce Mattock, BCH)

It is likely. Primarily TSS during in-stream works

f. Will dam construction potentially affect any groundwater aquifers where shallow wells may be drilled to service the camp? (Kyle Robertson)

Materials provided to Urban Systems

Note: the water tested within the adits may be affected by shotcrete, steel rebar, etc and other materials and processes associated with the adit structures and that this data may not be representative of typical groundwater.

Questions – General:

1. Worker Housing: (Erin)

a. Are the locations outlined in the memo dated Sept 16, 2011 still current? Could these

locations change significantly?

The North Bank Camp will be located very close to location on map.

The South bank Camp is expected to move to the East, away from wetlands, but not a significant distance. A map is being updated.

Urban Systems asked on elevation change (not significant).

b. Populations – The peak populations for each camp are provided.

South Bank: 1200 / North Bank: 500

How will these populations vary seasonally and through the course of construction?

North Bank camp population will be fairly..

The South Bank camp workforce population will vary significantly by year and season.

See workforce population charts attached for reference (confidential).

How many people could require service post construction for offices/powerhouse at the north bank site?

(Richard)

Approximately 16 regular with peaks up to 50 and 100. Urban Systems is currently working on this issue with Peace Canyon and understands challenge.

c. Are there any more details available about the proposed camps?

Subject: Preliminary Servicing Requirements for Worker Housing at Peak Capacity Scenario
Attention: Fort St. John and Peace River Regional District, CAO and Staff
Date: September 16th, 2011.
From: Siobhan Jackson, Erin Harlos, BC Hydro
Site C Engineering Team, BC Hydro

Background

This memo provides a preliminary overview of the servicing requirements for a peak capacity scenario for the proposed Site C Project's dam site construction worker housing. Sharing initial information on service infrastructure planning for dam site worker housing follows from earlier discussions with local government on preliminary worker housing planning.

A discussion with the Peace River Regional District and Fort St. John on servicing requirements for worker housing and longer term site servicing are important for BC Hydro's early planning. Servicing infrastructure on the North Bank will be required to support a worker housing camp during construction, and could potentially support permanent connection of the completed dam powerhouse and buildings to the local sewage and water systems. BC Hydro is interested to receive input on long term service infrastructure planning and interests in the area.

Please note that the activities described within this memo are based on the preliminary construction planning and assumptions and this information will be updated over the course of Stage 3. Activities, labour requirements and schedules may be different depending on final design and procurement, including contractor preferences, methods, and costing considerations. Please treat all numbers and capacity references as preliminary and draft.

Purpose

The purpose of this document is to provide local and regional government staff with an introduction to the project's potential worker housing servicing requirements for a peak dam site worker housing scenario. We would like to request that you review the information in preparation for a technical discussion in the near future. This memo includes the following sections:

1. In-Service Dates and Preliminary Siting for Dam Site Worker Housing Camps
2. Water Supply, Treatment and Distribution
3. Waste Management
4. Sewage Treatment
5. Electricity / Telecommunications
6. Decommissioning or Long Term Serving Planning
7. Worker Housing Social Services

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1. In-Service Dates and Preliminary Siting for Dam Site Worker Housing Camps

This memo considers the peak capacity scenario for the North and South Bank Dam Site worker housing camps for a population of 1700 workers. This conservative approach has been taken to plan for the maximum servicing requirements. The worker housing camps at the dam site will be completed in two stages, with occupation at the North Bank beginning first and ending last.

Worker Housing Location	Worker Housing Populations at Peak Capacity	In-Service Dates
North Bank Dam Site	500	Year 1 – 8 (Approx. 2014)
South Bank Dam Site	1200	Year 2 – 8 (Approx. 2015)

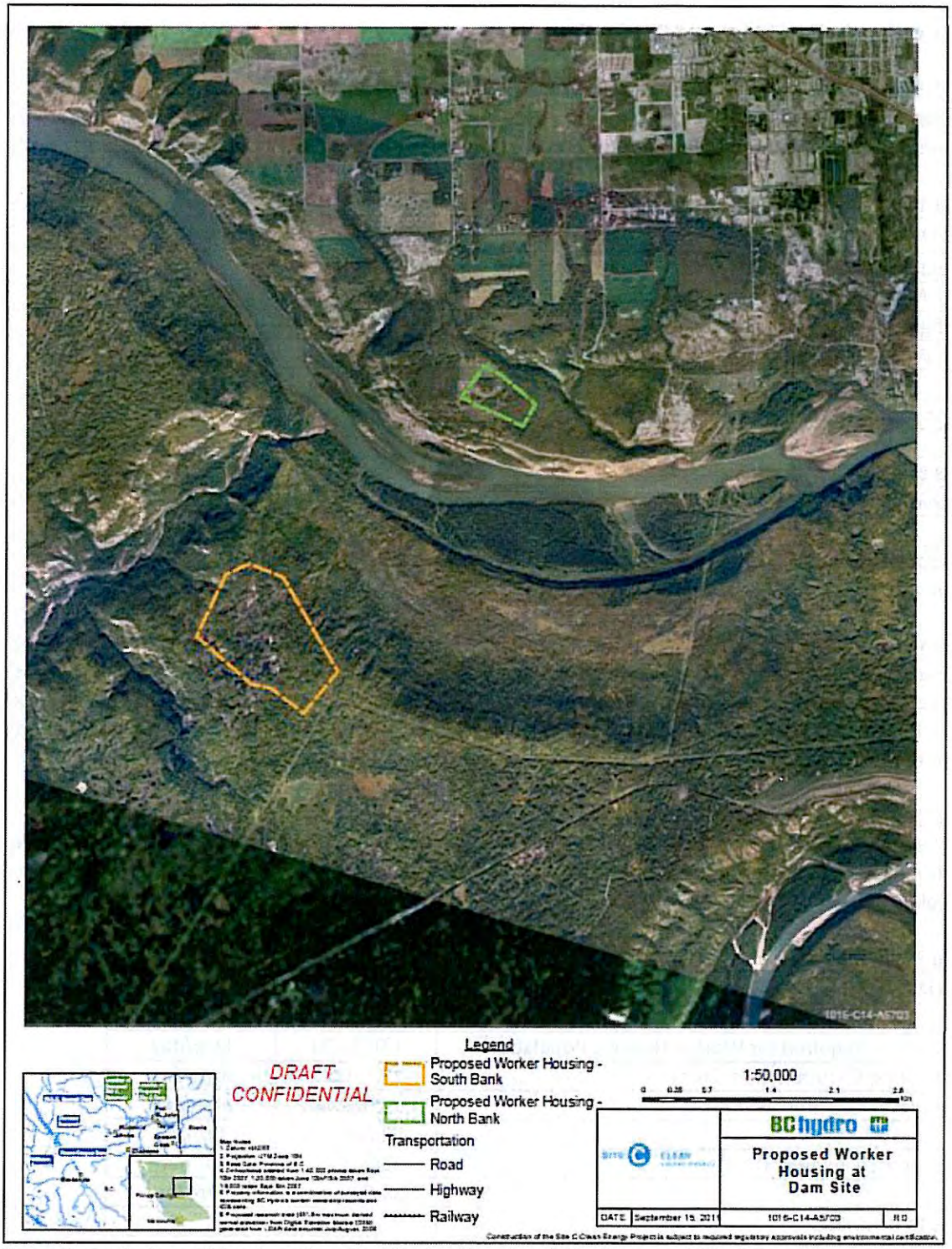

Figure 1: Preliminary Siting Locations for Worker Housing at the Proposed Site C Dam Site.

The preliminary location for the North Bank camp is outlined in Green, and for the South Bank camp in Yellow. These are preliminary worker housing locations, and may be moved within this general dam site area.

2. Water Supply, Treatment, and Distribution

Estimates of Water Consumption and Reservoir Sizes for North Bank Camp

For the peak worker housing population scenario, North Bank maximum capacity is 500. The water consumption required for residents' usage and fire protection purposes are estimated in Table 1.

Table 1 Estimates of the Water Consumption for North Bank Camp

Item Description	Quantity	Unit
Population	500	person
Total Water Required for Worker Housing Population[1]	425,813	litre/day
Fire-fighting Requirements (2hrs)	227,100	litre/day
Total Water Required per Day	652,913	litre/day
	27,205	litre/hr
Water source (well or river)[2]	150	gal/min
	34,065	litre/hr
Wells to be drilled (if applicable)	1	
Reservoir Size	240,000	Litre
	240	m3

1: A capacity factor of 1.5 is assumed.
2: An output of 150 gal/minute is assumed.

According to the estimate, one well is required at the North Bank camp. This assumes that the water is not coming from the City of Fort St. John's network and is based on water storage for emergency being required at half a day's person water consumption plus 2 hour fire-fighting requirements. Therefore, at North Bank camp site, a 240m^3 reservoir would be required to meet the emergency and fire fighting water requirements.

Estimates of Water Consumption and Reservoir Sizes for South Bank Camp

For the peak worker housing population scenario, the water consumptions required for residents' usage and fire protection purposes are estimated as follows for the South Bank 1,200 person Camp, as shown in Table 2 below.

Table 2 Estimates of the Water Consumption for South Bank Camp

Item Description	Quantity	Unit
Effective Population	1,200	person
Total Water Required for Worker Housing Population[1]	1,022,000	litre/day
Fire-fighting Requirements (2hrs)	227,100	litre/day
Total Water Required per Day	1,250,000	litre/day
	52,000	litre/hr
Water source (well or river)[2]	150	gal/min
	34,000	litre/hr
Wells to be drilled	2	
Reservoir Size	563,000	Litre
	563	m3

1: A capacity factor of 1.5 is assumed.
2: A output of 150 gal/minute is assumed.

According to the estimate, two wells would be required at the South Bank camp site. This assumes water storage for emergency is half a day's water consumption plus 2hr fire-fighting requirements. Therefore, at South Bank camp site, a 724m^3 reservoir would be required to meet the emergency and fire fighting water requirements.

North Bank Camp Water Systems

The North Bank Camp water system planning requires discussion with Fort St. John and the Peace River Regional District to assess the capacity of the water system to support potable and fire-fighting water requirements. The discussion will require assessment of cost, feasibility and location of a potential connection.

South Bank Camp Water Systems

For the South Bank camp, it is assumed that two wells would be drilled or an intake in the river would be built to supply raw water. Raw water would be treated by a temporary water treatment plant installed at the camp. It is assumed that a 700m^3 temporary reservoir would be built for emergency and fire protection requirements. Concrete type water reservoir is recommended because it can be constructed at the same time when the foundations of the water treatment facilities being built.

3. Preliminary Project Waste Management Considerations

There are two divisions of waste management for consideration; worker housing waste and site waste produced during construction. This memo only addresses worker housing waste at a preliminary level. As part of project servicing planning, discussion is required with Fort St. John and the Peace River Regional district on solid waste management in the region.

Waste from Worker Housing Facilities

For waste management planning purposes, the population for the left bank and the right bank is estimated to be 500 people and 1200 person. The waste from the two camps on both the left and right banks would include waste similar to residential waste including the followings:

- Food waste will be generated from the kitchen. This includes table waste, processing waste, spoiled food, grease, oil and liquids.
- Solid waste such as plastic, paper, cardboard, glass, metal.
- Sewage and waste water.

Waste from camp facilities will be diverted to recycling and composting whenever possible, as outlined in Table 3 below.

Table 3 Waste Disposal Solutions Proposed for Worker Housing for Site C Project

Waste	Recycle	Landfill	Compost within Landfill	Incineration	Treatment
Food waste		X	X	X	
Grease/oil	X			X	X
Food liquids		X	X	X	X
Sewage / liquids		X		X	X
Plastic	X			X	
Paper/Cardboard	X		X	X	
Metal	X				X
Glass	X				X

Preliminary waste quantities generated from the North and South bank worker housing camps (with total peak population of 1,200) are estimated below. The total amount of waste is estimated to be 2,700 tonnes and if landfilled would require 6,300 m^3 in size.

Table 4 Waste Generations Estimates for Dam Site Worker Housing for Site C Project

Waste Disposal	Total Waste Generated during Construction Phase	Total Recycled	Total Composted	Total Incinerated or Land-Filled
lb/person/day	4.34	1.09	0.37	2.87
Total in Tonnes by Population	4,100	1,000	350	2,700

4. Preliminary Sewage Treatment Overview

Estimates of Sewage Flow Quantity and Sewage Collection

The average daily flow quantities of sewage for the 500-man north bank camp and 1200-man south bank camp are estimated in the following tables.

Table 5 Estimates of the Sewage Flow for the North Bank Camp

Item Description	Quantity	Unit
Estimated Peak Population	500	person
Average Daily Flow	326	m3/day
Maximum Month Daily Loading[1]	555	m3/day
Maximum Day Peak Flow[2]	1,044	m3/day

1: A maximum month peak factor of 1.7 is assumed.
2: A maximum day peak factor of 3.2 is assumed.

The estimated average sewage flow for the North Bank camp is 320m3/day (with daily average in summer 555m3/day), and the maximum daily flow would be 1,044m3/day.

Table 6 Estimates of the Sewage Flow for the South Bank Camp

Item Description	Quantity	Unit
Estimated Peak Population	1,200	person
Average Daily Flow	780	m3/day
Maximum Month Daily Loading[1]	1,330	m3/day
Maximum Day Peak Flow[2]	2,500	m3/day

1: A maximum month peak factor of 1.7 is assumed.
2: A maximum day peak factor of 3.2 is assumed.

The estimated average sewage flow for the South Bank camp is 780 m^3/day (with daily average in summer 1,330m^3/day), and the maximum daily flow through a year would be 2,500m^3/day.

Sewage Collection

It is assumed that sewage water would be collected through pipelines and collecting wells from camp areas and would flow by gravity to sewage lagoons or treatment plants.

Sewage Treatment and Discharge

It is assumed that the sewage from the camps would be treated by a sewage lagoon specially built for this project on each side of the river for the North and South Bank worker housing camps.

For the North Bank camp, a north sewage treatment lagoon would be built on the North Bank. Treated effluent would be discharged from the north lagoons into the Peace River on a continuous basis (or a designated time period during spring and fall, based on requirements). Options for re-use of treated water will be considered within project planning to reduce total water requirements. The lagoon could be designed and built for temporary use, or longer term use. A discussion with the PRRD and Fort St. John is recommended to determine interests in sewage treatment facilities in this area.

A south sewage treatment lagoon would be built on the South Bank for the South Bank 1,200-man camp. Treated effluent would be discharged from the south lagoons to the Peace River on a continuous basis (or a designated time period during spring and fall, based on requirements). Again, options for re-use of treated water will be considered within Project planning to reduce total water requirements.

5. Electricity and Telecommunications

Electricity would be required for the worker housing camp sites, and provided by BC Hydro via an extension of existing distribution infrastructure, or a temporary portable substation on the South Bank, or both. In addition to the primary camp facilities, other Camp Utilities that will require electricity including: Heating and Air-conditioning; Fire Fighting Water Systems; Fire Alarm and Detection; Indoor Lighting; Outdoor Lighting; Power supply and distribution; and Emergency power. Propane and/or gas may be used within kitchen and catering facilities and would be provided via temporary tanks. Additional details will be included in future design stages for the project.

The typical standards for telecommunications servicing of worker housing would be provided including wireless coverage, internet connectivity and pay phones on-site will be provided. A central telecommunication system will be set up in the camp area in support the project.

6. Decommissioning or Long Term Servicing Planning

Planning the servicing for the temporary worker housing sites may have different approaches depending on the long term interest in infrastructure in the area. A consideration of long term community and regional interests in developments and infrastructure is needed. This specifically applies to the North Bank site as servicing infrastructure could potentially support permanent connection for the completed dam powerhouse and buildings to local sewage and water systems.

If the Peace River Regional District and the City of Fort St. John do not have an interest in partnering options related to long term infrastructure, the project would plan to meet all needs using stand alone or temporary infrastructure with full site decommissioning.

7. Worker Housing Social Services

Security

The Project would have security personnel at all worker housing and construction site access points. Each camp would have its own security personal and procedures.

Fire Protection

Fire alarm, detection and fire protection water systems would be incorporated into planning the North and South Bank worker housing. Fire protection, including fire fighters for the dam site construction area, would include coverage of worker housing. Shared resources or agreements would be discussed with local and regional governments.

Medical

Onsite first responders and emergency transportation would be planned for the North and South Bank worker housing sites and work sites. Additional project medical staff including a doctor and nursing support would be planned for the dam site work area; with potential for the doctor to be located either on-site or in an off-site community medical facility.

Addressing broader health and wellness needs may include on-site resources, off-site resources or a shared regional resourcing approach. Shared resources and agreements for coverage is an area for discussion.

Site C Camps
Water & Sewer
Feasibility Study

Report

FINAL -
CONFIDENTIAL

Appendix E

Golder Water Quality Reports

1076.0057.01 / May 24,
2012

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10808 - 100th Street, Fort St. John BC V1J 3Z6
Telephone: 250-785-9697

URBANSYSTEMS.

February 17, 2012 File: 1076.0057.01

List of Golder Reports and letters that provide water quality data of the Peace River and Groundwater reviewed as part of this study. Additional water quality analysis is required as part of the design phase of water servicing.

1) "Water Quality, River Sediment, Soil, and Vegetation Samples from the Peace River Watershed – 2007," Golder and Associates, Report Number: 06-1490-006, May 15, 2009

2) "Baseline Data Collection – Peace River Watershed Water Quality and Dinosaur Lake Limnology Sampling – 2008," Golder and Associates, Report Number: 08-1430-0016, August 2009

3) "BC Hydro Site C Clean Energy Project – Adit 3 Water Sample Analysis," Golder and Associates, Project No. 09-1422-0014, January 6, 2011

4) "BC Hydro Site C Clean Energy Project – Adit 3 Water Sample Analysis," Golder and Assocaites, Project No. 09-1422-0014, August 29, 2011

5) "BC Hydro Site C Clean Energy Project – Adit 4 Water Sample Analyses," Golder and Assocaites, Project No. 09-1422-0014, November, 2011

The City of Fort St John water quality results from the wells are attached.

Location City of Fort St. John Aquifer
Project Various for analyses

RESULTS OF ANALYSES

Results are expressed as milligrams per litre except where noted.

							Guideline Values from GCDWQ			
ALS File No.										
Date Received	10/06/1998	01/10/1998	26/08/2003		26/08/2003					
Date:	08/06/1998	28/09/1998	23/08/2003		25/08/2003					
Location Sampled	TPW-5	TPW-6	TPW-7		TPW-7		MAC	AO	IMAC	value of note	footnote
Date Sampled	08/06/1998	28/09/1998	23/08/2003		25/08/2003						
Time Sampled			11:00am		11:00am						
laboratory	Agal	Agal	ALS		ALS						
Sample ID	F27343	F31272.405	T3105.1		T3105.2						
Nature											
Physical Tests											
Colour (CU)		5	<5		<5						
Conductivity (uS/cm)	310	220	290		286						
Total Dissolved Solids	215	155	158		168			≤ 500			
Hardness CaCO3	163		139		137						
pH	7.8	8.0	8.13		8.16			6.5-8.5			
Turbidity (NTU)		0.51	1.6		1.7		1	≤ 5			(1)
Dissolved Anions											
Alkalinity-Total CaCO3	152	128	129		126						
Chloride Cl	1.4	0.6	<0.5		<0.5			≤ 250			
Fluoride F	0.1	0.1	0.07		0.07		1.5				
Silicate SiO2											
Sulphate SO4	39	19.5	25		23			≤ 500			
Nutrients											
Ammonia Nitrogen N			0.04		0.03						
Total Kjeldahl Nitrogen N			0.07		0.06						
Nitrate Nitrogen N	<0.4	<0.4	<0.1		<0.1		10				
Nitrite Nitrogen N	<0.3	<0.3	<0.1		<0.1						
Organic Nitrogen N											
Total Nitrogen N											
Dissolved ortho-Phosphate P			0.001		0.001						
Cyanides											
Total Cyanide CN			<0.005		<0.005		0.2				
WAD cyanide			<0.005		<0.005						
Bacteriological Tests											
E. coli					<1		0				
Coliform Bacteria - Fecal					<1		0				
Metals			T-Metals	D-Metals	T-Metals	D-Metals					
Aluminum		<0.02	<0.01	<0.01	<0.01	<0.01	0.1				
Antimony		<0.001	<0.0005	<0.0005	<0.0005	<0.0005			0.006		
Arsenic		<0.001	<0.001	<0.001	<0.001	<0.001			0.025		
Barium		0.148	0.08	0.08	0.08	0.08	1				
Beryllium		<0.001									
Bismuth											
Boron		<0.02	<0.1	<0.1	<0.1	<0.1			5		
Cadmium		<0.001	<0.0002	<0.0002	<0.0002	<0.0002	0.005				
Calcium	47.5	42.2	41.5	40.7	41.5	40.0					
Chromium		<0.01	<0.002	<0.002	<0.002	<0.002	0.05				
Cobalt		<0.01									
Copper		0.022	<0.01	<0.001	<0.01	<0.001		≤ 1			
Iron	0.024	0.071	0.30	0.27	0.27	0.28		≤ 0.3			
Lead		<0.01	<0.001	<0.001	<0.001	<0.001	0.01				(3)
Lithium		<0.008									
Magnesium	10.9	8.2	9.0	9.2	9.0	9.0					
Manganese	***0.315***	***0.198***	***0.244***	***0.254***	***0.219***	***0.214***		≤ 0.1			
Mercury		<0.0001	<0.0002	<0.0002	<0.0002	<0.0002					
Molybdenum		<0.001									
Nickel		<0.0006									

Water Quality Data TPW-5, 6 7, City of Fort St. John

Location Sampled	TPW-5	TPW-6	TPW-7		TPW-7		MAC	AO	IMAC	value of note	footnote
Phosphorus											
Potassium	<0.6	<0.6	0.6	0.6	0.6	0.6					
Selenium		<0.001	<0.001	<0.001	<0.001	<0.001	0.01				
Silicon	-	2.87									
Silver		<0.002									
Sodium	1.6	1.8	5	5	4	5		≤ 200			
Strontium		0.149									
Thallium		<0.01									
Tin		<0.004									
Titanium		<0.004									
Uranium			0.0003	0.0003	0.0003	0.0002			0.02		
Vanadium		<0.004									
Zinc		0.02	<0.05	<0.05	<0.05	<0.05					
Organic Parameters											
Dissolved Organic Carbon C											
Total Organic Carbon C			1.9		1.4						
Radiological Parameters (Gross α,β)											
Gross α		Bq/L	<0.07		<0.08					0.1	(4)
Grossβ		Bq/L	<0.05		0.05					1.0	(4)

Footnotes:

Coliform results are expressed as Colony Forming Units (CFU) per 100 mL.

< Less than the method detection limit (MDL)

(a) Gross Alpha and Beta analysis subcontracted to SRC, units are Bq/L

(1) may be waived/ re-evaluated for groundwater

(2) values in excess of *value of note* indicate requirement for re-sampling

(3) at point of use

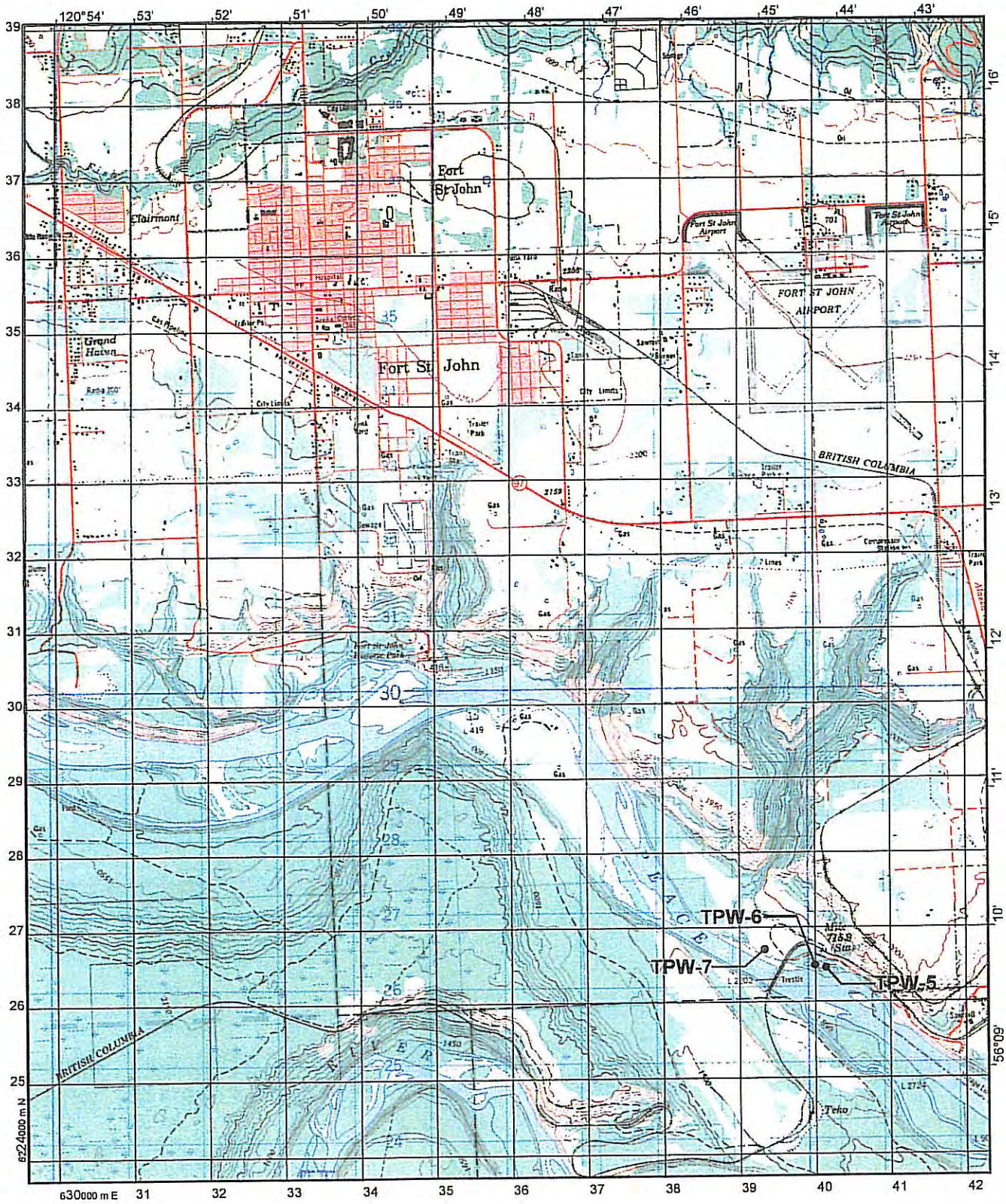
(4) exceedence of value of note indicates requirement for radionuclide specific testing

Exceedences

0.0157 indicates values exceeding the MAC in GCDWQ

0.195 indicates values exceeding the AO in GCDWQ

0.0108 indicates values equalling the the MAC in GCDWQ when rounded to the same significant numbers as the MAC



0 m 1875 m 3750 m

Scale 1 : 75 000

Golder Associates

CITY OF FORT ST. JOHN

KEY PLAN

Drawn: CDC	App'd: NJS	Date: Mar-01-04	Figure: 1

Project No.: 03-1430-052

Revision No.:

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Site C Camps
Water & Sewer
Feasibility Study

Report

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Appendix F

List of Water System Assumptions

1076.0057.01 / May 24,
2012

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URBANSYSTEMS.

May 24, 2012 File: 1076.0057.01

North and South Bank Camp Water Servicing – List of General Assumptions

1) Design flows for both camps are based on water demands provided by BC Hydro.
2) Assumes that the Total Water Required Per Day water demands provided by BC Hydro equal the Maximum Day Demand.
3) BC Hydro indicated that onsite storage within the camps will be used for fire storage and to accommodate peak flows therefore the water supply systems are based on providing the maximum day demands.
4) The City of Fort St. John draws water from groundwater that is approximately 7-14m below grade in the river valley therefore it is assumed that the pumping requirements (static head) will be similar for both groundwater and surface water.
5) Assumes that an intake and a suitable groundwater well can be located within the area shown within the report. The actual locations of the intake and groundwater wells requires additional consultation/analysis with river hydraulics and groundwater specialists.
6) Assumes that the pumping system consists of two pumps, each with the capacity to deliver the full design flow (100% redundancy).
7) Assumes that the pumps will be sized to deliver the water demands in 21 hours to allow a couple hours of downtime per day for maintenance.
8) Assumes backwash waste is 10% of the total volume raw water that will be wasted during the treatment process.
9) Summary of the raw water pumping conditions used in this study is summarized in the table below:

Design Assumptions	North Camp	South Camp
Maximum Daily Demand (m^3/day)	660	1,350
Redundancy	100%	100%
Number of Pumps	2	2
Pumping Time (hrs/day)	21	21
Backwash Waste	10%	10%
Design Flow per Pump (L/s)	9.60	19.64

10) The water treatment elevation assumes the water treatment plant will be located within the camp boundaries as depicted in memo titled Preliminary Servicing Requirements for Workers Housing at Peak Capacity Scenario dated September 16, 2011. Elevations of the water treatment plants within the camp boundaries based on highest elevation as per Google Earth.
11) The length of the raw water supply line assumes a straight water line between the intake and the water treatment plant. The actual alignment and corresponding length of the raw water

supply line should be reviewed in detail and should include a geotechnical investigation to ensure soil stability.

12) Pump horsepower requirements assumes a pump efficiency of 75%.
13) Summary of the elevations used to determine the pumping requirements for the two camps are summarized in the table below:

Design Assumptions	North Camp	South Camp
Peace River Low Water Elevation	409 m	409 m
Assumed Groundwater Elevation$_1$	399 m	399 m
Water Treatment Plant Elevation$_2$	584 m	646 m
Static Head	175 to 185 m	237 to 247 m
Raw Water Supply Line$_3$	1,200 m	2,600 m
Raw Water Supply Line Diameter$_4$	200 mm	100 mm
Pump Horsepower Required$_5$	40 HP	100 HP

Camp Water Servicing – List of Standalone Cost Estimate Assumptions

1) Due to the static pressure at the lower end of the raw water supply line, the cost estimate assumes that steel piping will be used for the lower 1 km of supply line will be steel for the South Bank Camp raw water supply line and the lower 200m for the North Bank Camp raw water supply line.
2) Assumes a modular treatment building will be utilized for the South Bank Camp.
3) Assumes North Bank Camp water treatment building will be a permanent building.
4) Cost estimate does not include cost for land or easements that may need to be purchased.
5) All building cost estimate include an allowance for a chlorine room and a small office/lab. No bathrooms or other potential building costs are included in the estimate.
6) Costs for siteworks or access roads to the treatment plants or pumping stations have not been included in the cost estimate.
7) No allowance for drainage or ground stabilization has been included in the cost estimate.
8) There is limited information about the proposed power supply to the camps and therefore no cost has been included for the power supply to any of the treatment plants. A cost allowance was included to supply power to the pumping station.
9) Water treatment plant electrical, controls and instrumentation estimates were based on limited information. Additional analysis required to refine the functionality and the types of controls for the processes.
10) Emergency standby power was is not included in the water supply or treatment cost estimate.
11) Cost estimate does not include water storage or distribution piping.

12) Cost estimate does not include operation and maintenance costs.

Camp Water Servicing – List of CFSJ Connection Cost Estimate Assumptions

1) The watermain upgrades within City limits includes the looping of the water system but does not include the cost for fire hydrants, services lines or any other infrastructure requirements. The ultimate upgrades requirements within City limits should be reviewed with the City.
2) The installation of the 100mm and 300mm water supply lines assume that the water lines will be installed within the boulevard and assumes that minimal site restoration (including drainage and bank stabilization is required.
3) Cost estimate does not include cost for land or easements that may need to be purchased.
4) The electrical, SCADA and radio communication estimates is an estimate for the pressure reducing stations. Depending on the level of control BC Hydro and the City would like to have at these station, additional equipment/cost may be required at the pressure reducing/sustaining stations.
5) Cost estimate does not include power supply cost to bring power to the pressure reducing/sustaining stations.
6) Does not include re-chlorination equipment.
7) Emergency standby power was is not included in the cost estimate.
8) Cost estimate does not include upgrades required for upgrades to the City of Fort St. John's water system.
9) Cost estimate does not include water storage or distribution piping.
10) Cost estimate does not include operation and maintenance costs.

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Appendix G

List of Wastewater System Assumptions

1076.0057.01 / May 24,
2012

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February 17, 2012 File: 1076.0057.01

Sanitary Wastewater System – List of Assumptions for Cost Estimate, General

1. BC Hydro provided estimated population and flow values that were used for cost estimation.
2. Terminology provided by BC Hydro was interpreted as follows:
    a. Daily Hydraulic Loading = Average Day Flow
    b. Day Peak Factor = Peaking Factor
    c. Peak Flow = Maximum Day Flow
3. Sanitary waste will flow by gravity from camps to onsite pump station wet well or primary treatment facility.
4. North Bank Camp wet well assumed elevation for pumping is 570 m.
5. Cost to install gravity piping from camps to pump stations is not included in scope.
6. Septic tank for primary treatment is estimated to be a rectangular cast in place concrete tank with baffle to hold two days of average day flow, approximately 550 m^3.
7. Pumps were chosen to accommodate maximum day flows at peak camp population.
8. Pumps will discharge wastewater through a forcemain from onsite wet well to treatment facility.
9. Forcemain will be HDPE or PVC installed 2.5 m below ground surface.
    a. No transient analysis was computed – pipe material may change depending on results to accommodate increased pressures or geotechnical soil stability. Additional components may be necessary, such as a surge tank, depending on further analysis. These possible design changes are identified here but no costs are included.
    b. Forcemain estimate includes check valves and air relief stations
    c. Forcemain will be installed adjacent to existing roadways where possible.
    d. Road crossings will be done using trenchless methods.
    e. Property acquisition or right of-way approvals, and any associated fees, are not included in the cost estimate. It is assumed that space is available for infrastructure and that there are no conflicts.
10. Ministry of Transportation approvals are assumed for installation of all forcemains in road right-of-ways.
11. No operation and maintenance costs are included in the cost estimates. Sources that require this could include:
    a. Pump maintenance
    b. Septic tank clean out
    c. Forcemain video inspection
12. No odour control measures are included in the cost estimate.
13. The pump stations will be underground with a heater to prevent freezing during low flow conditions. There will be an above surface kiosk for electrical controls.
14. Pump station capital costs include all interior piping, valves, components, and concrete support bases, and vent and drain pipes. Flow meters are not included.
15. There will be 3-phase power available to pump stations. There is no cost included in the estimate to provide 3-phase power to the pump station locations.
16. The Electrical and SCADA estimate includes the cost for pump stations' wiring, PLC, and SCADA integration.
17. An emergency standby power source (diesel genset) is included in the pump station capital costs.
18. Sewer capacity was analyzed to accommodate BC Hydro's maximum daily flows. It is preferred to analyze lagoon treatment systems using a maximum month capacity; however, because there is no actual sewer flow data from the North Bank camp to determine maximum month flows, the average day and maximum daily flow rates were used.

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Sanitary Wastewater System – List of Assumptions for Cost Estimate, PRRD Specific

1. PRRD will allow BC Hydro to connect to the Charlie Lake Lagoons.
2. BC Hydro will likely be required to pay a service fee to The PRRD for treatment of wastewater. This fee is not included in the estimate.
3. As the Charlie Lake Lagoons are near capacity, BC Hydro will likely have to pay for upgrades to the lagoons and treatment system. This cost is not included in the estimate.
4. Disposal of solid waste, collected during primary treatment, is not accounted for in the cost estimate.
5. The discharge elevation for the Charlie Lake Lagoons is 733 m.

Sanitary Wastewater System – List of Assumptions for Cost Estimate, CFSJ Specific

1. The CFSJ will allow BC Hydro to connect to the South Sewage Treatment Plant (SSTP).
2. BC Hydro will likely be required to pay a service fee to The CFSJ for treatment of wastewater. This fee is not included in the estimate.
3. BC Hydro will likely be required to pay for a portion of existing/upcoming piping and treatment infrastructure, relative to their use. This cost is not included in the estimate.
4. The forcemain will discharge into Control Manhole #1 at the SSTP – an elevation 674 m. Options to discharge into CFSJ's gravity system were considered. Use of the existing gravity system was not included within the report due to the following:
    a. It will take up existing pipe capacities – a more detailed analysis would be necessary.
    b. Wastewater would have to be pumped again at the South Sewage Lift Station to enter the SSSTP.
    c. Low flows from BC Hydro could result in high odours as it enters the gravity system.
    d. Increased costs for use of infrastructure. Possible upgrades to gravity piping and lift station pumps may be required.