Bowser Village Wastewater Servicing Design Report

Prepared for:
Regional District of Nanaimo

Prepared by:
Stantec Consulting Ltd.

April 7, 2017

Sign-off Sheet

This document entitled Bowser Village Wastewater Servicing Design Report was prepared by Stantec Consulting Ltd. ("Stantec") for the account of the Regional District of Nanaimo (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ____
(signature)

David Lycon, Ph.D., P.Eng.

Reviewed by ____
(signature)

Stan Spencer, P.Eng.

Table of Contents

Appendices

- TM 1 – Bowser WWTP – Treatment Technology Options Analysis, October 23, 2015
- TM 2 – Revision 2 – Bowers WWTP – Effluent Disposal Option Analysis, April 25, 2016
- TM 3 – Revision 1 – Bowser WWTP – Environmental Studies and Permitting Considerations, March 10, 2016
- TM 4 – Bowser Village Centre Wastewater System – Desktop Environmental Review, May 30, 2016

EXECUTIVE SUMMARY

Bowser Village is located on the east coast of Vancouver Island and is within Electoral Area-H of the RDN. It is approximately 66 km northeast of the City of Nanaimo and almost 38 km southwest of the City of Courtenay. The current population for the Bowser Village Centre is estimated at 188 (80 units).

The new wastewater system being proposed will be required to service the existing developed properties in the Bowser Village Centre, and provide sufficient capacity to allow for future service to the Future Use Area. Using the 2016 population of 188, which has been extrapolated from Statistics Canada data, and applying a 5% annual growth rate, results in a 2036 design population of 499 results. This data, along with the peaking factors developed for the proposed design flows is presented below.

Proposed Design Flows

Parameter	Value
Population	499
Average Dry Weather Flow (m^3/d)	200
Maximum Month Flow (m^3/d)	250
Maximum Day Flow (m^3/d)	400
Peak Hour Flow (L/s)	9.2

A Sequencing Batch Reactor (SBR) is the treatment process proposed for the Bowser Wastewater Treatment Plant. It will reduce the influent BOD and TSS concentrations to levels below that permitted by the plant's proposed operating certificate. Upstream of the SBR, the treatment process will include influent screening to remove inorganic material from the raw sewage and a splitter box will be provided to divert flows to each SBR unit. The treatment plant will include odour control for the headworks building (i.e. screening location) and the raw sewage splitter box. Ultraviolet disinfection will be provided for the effluent before being pumped off-site to either a marine outfall or ground disposal.

An onsite waste secondary solids storage/aerated sludge tank will be provided to store the residual stream generated by the SBR process before it is hauled off-site to the French Creek Pollution Control Centre (FCPCC) for further processing.

The proposed wastewater treatment plant building is a single storey stand-alone structure that contains the process and mechanical/electrical equipment, along with a control room / administration area. The proposed building will be situated amongst the tanks associated with wastewater treatment process. The building will be of non-combustible and combustible materials as required to meet code and service requirements. The proposed treatment plant location is approximately 0.5km from Highway 19A and a 7.0m wide gravel access road will need to be constructed from the intersection of Highway 19A and Sundry Road to the site. A new 100mm water service for the WWTP will connect to the Bowser Water Works system at the intersection of Highway 19A and Sundry Road and a new 250 kVa electrical service will be required with a pad mounted transformer located on-site.

The WWTP effluent disposal options were evaluated and two options were identified for marine disposal. No suitable option was found for ground disposal. The two marine disposal options are presented in Appendix B.

The sewage collection system includes a gravity sewer and 3 pump stations to pump the sewage to the WWTP from various low points. This design will utilize a 200mm minimum diameter gravity system capable of handling the anticipated ultimate build out conditions and one section of gravity main is proposed to be 150mm diameter and this will be along Park Avenue, as the sewer line cannot be extended further and the collection area is relatively small. The catchment area is shown in the Appendix A, Figure 4.1.

The cost estimate for the Bowser Village Wastewater Servicing is summarized below.

Cost Estimate - Summary

Item	Cost Estimate
Wastewater Treatment Plant	$4,091,000
Collection System	$4,052,000
Marine Outfall (Option A or B)	$2,341,000 to $2,990,000
Permitting, Archaeological, Engineering	$788,000
TOTAL	**$$11,272,000 to $11,921,000**

The WWTP and collection systems costs are based on a Class A estimate and the outfall costs are based on a Class C estimate.

1.0 INTRODUCTION

1.1 General

Stantec Consulting Ltd. (Stantec) was retained by the Regional District of Nanaimo (RDN) to undertake the detailed engineering for the Bowser Village Wastewater Servicing. This design report summarizes the details of the final design.

The design meets BC Ministry of Environment's Municipal Effluent Regulation ("MWR') effluent criteria, minimizes life cycle costs, and provides a logical plan for the build-out of the proposed service area, while staying within RDN's established capital budget.

1.2 Report Content

This design report is organized into 10 sections:

Section 1	Introduction
Section 2	Design Flows and Loads
Section 3	Process Design
Section 4	Civil Design
Section 5	Architectural Design
Section 6	Structural Design
Section 7	Building Mechanical Design
Section 8	Electrical Design
Section 9	Instrumentation and Controls Design
Section 10	Cost Estimate

A detailed design drawing package has been submitted to complement this report (bound separately).

1.3 Background

Bowser Village is located on the east coast of Vancouver Island and is within Electoral Area-H of the RDN. It is approximately 66 km northeast of the City of Nanaimo and almost 38 km southwest of the City of Courtenay. The current population for the Bowser Village Centre is estimated at 170 (80 units).

The new wastewater system being proposed will be required to service the existing developed properties in the Bowser Village Centre, and provide sufficient capacity to allow for future service to the Future Use Area. Detailed design work has already been undertaken for the collection system and the means of final effluent disposal. The reports that summarize this work have been provided in the Appendices. The detailed design also follows on from the Bower WWTP Pre-Design Concept Report, dated March 28, 2016 and the Treatment Technology Options Analysis technical memorandum that was prepared for the RDN in December 2015 (Appendix C). This information provided a recommendation for the main secondary treatment option which would allow the Village to meet the treatment objectives for this project. As part of the analysis, the sequencing batch reactor (SBR) process was selected.

1.4 Proposed Bowser WWTP

The proposed Bowser WWTP will include the following unit processes/systems:

- Fine screens (6mm perforated plate);
- Screened raw sewage splitter box;
- Sequencing batch reactors (SBRs);
- Process air system including blowers and diffusers;
- Secondary effluent equalization tank;
- Secondary effluent pumps;
- Ultra violet disinfection; and
- Aerated sludge tank.

1.5 Regulatory Requirements

Due to the lack of favourable conditions for ground disposal for the effluent, the treatment plant has been designed based on the assumption of marine disposal. The proposed discharge limits are as summarized in **Table 1.1**. These effluent criteria adhere to the requirements of the BC Municipal Wastewater Regulations (BCMWR) and take into account the initial dilution zone.

Table 1.1 – Proposed BC MWR Effluent Requirements for the Bowser WWTP

Parameter	Limit
BOD5 (mg/L)	≤ 45
TSS (mg/L)	≤ 45
Fecal Coliform - at the edge of the initial dilution zone (MPN/100 Ml)	200

Table 1.2 – Federal Wastewater System Effluent Regulations ("WSER")

Parameter	Limit
cBOD5 (mg/L)	≤ 25[1]
TSS (mg/L)	≤ 25[1]
Un-ionized Ammonia (@15 °C) (mg/L)	≤ 1.25
Total Chlorine Residual (mg/L)	≤ 0.02

[1] Quarterly arithmetic mean of monthly grab samples

2.0 DESIGN FLOWS AND LOADS

As the proposed Bowser WWTP is a greenfield plant, data for the Village's wastewater in not available. This is both in regards to quantity and quality. As such, assumptions will be made in the development of the design flows and pollutant loads that will be used to size the various process systems. The following subsections outline the basis of design for each of the flows and loads.

2.1 Design Population

The design populations that were used in Technical Memorandum (TM) 1 were based on the 2011 Chatwin Engineering report entitled, Feasibility Study for Area-H Bowser Community Sewer Servicing Study. However, since the delivery of this TM a more critical review of the projected populations has been undertaken as part of the sanitary sewer collection systems design (Appendix A). The sanitary sewer design report, in consultation with the RDN, has indicated the growth projected in the Chatwin Engineering report is optimistic, and the use of excessively high population density targets is not the best approach. Stantec believes that a uniform growth based on a conventional 5% growth per year should be used for the next 20 years to calculate a more realistic system build out. In using a 2016 population value of 188, which has been extrapolated from Statistics Canada data, and applying a 5% annual growth rate, a 2036 design population of 499 results. This is only slightly higher than the Phase 1 design population of 445 that was outlined in TM 1.

2.2 Design Flows and Loads

This data, along with the peaking factors developed for Technical Memorandum 1, is presented in **Table 2.1**. A similar exercise has been conducted for the plant loading, with results presented in **Table 2.2**.

Table 2.1 – Proposed Design Flows

Parameter	Value
Population	499
Average Dry Weather Flow (m^3/d)	200
Maximum Month Flow (m^3/d)	250
Maximum Day Flow (m^3/d)	400
Peak Hour Flow (L/s)	9.2

Notes:

1) Average day flow= 400 L/c/d
2) Maximum month peaking factor= 1.25
3) Maximum day peaking factor= 2.0
4) Peak hour flow from sanitary collection system design

Table 2.2 – Design Load Information

Parameter	Phase 1 Year 2036
Population	499
Per Capita BOD (kg/cap d)	0.080
Average BOD Load (kg/d)	40
Maximum Month BOD Load (kg/d)	50
Per Capita TSS (kg/cap d)	0.090
Average TSS Load (kg/d)	45
Maximum Month TSS Load (kg/d)	56
Per Capita TKN (kg/cap d)	0.022
Average TKN Load (kg/d)	11
Maximum Month TKN Load (kg/d)	14
Per Capita TP (kg/cap d)	0.003
Average TP Load (kg/d)	1.5
Maximum Month TP Load (kg/d)	2.0

Notes:

1) Maximum month peaking factor= 1.25
2) Maximum day peaking factor= 2.0

The flow and load data presented above, and the effluent quality criteria presented in Section 1.5 will form the basis of design for the unit treatment processes that will be discussed in Section 3.

3.0 PROCESS DESIGN

This section presents the design criteria for major process equipment for the current plant design. As part of the assessment of design criteria, staging of equipment capacity has been considered to facilitate future upgrades.

3.1 Influent Screening

Flow from the sanitary sewer collection system will be pumped to the Operation Building. A provision is included in the design to allow for the addition of an influent flow meter in the future. It will enter into the building's Screening Room where it will flow into an influent channel. This influent channel will then split into two channels; each of which will convey wastewater to one of two perforated plate auger-type mechanical screens. Discharge from the screening channels will tie into a common channel leading to the Screened Raw Sewage Splitter Box.

There will be a weir gate upstream of each mechanical screen. During operation, the weir gate in the duty screening channel will be completely open, where the one in the standby channel will be set at such an elevation as to allow flow to spill over the weir in the event of a blockage in the duty screening channel. The bottom of the screening channels will be flush with the elevation of the building's floor slab. The screening room will also contain ample space adjacent to screens to allow for removal of a screen through a set of double doors. This space will also allow for the easy removal of the bin that will contain the bagged screenings.

Screen opening sizes have, over the years, been decreasing in size. Today, screens are generally equipped with openings that are 3 to 10 mm with a range of 5 – 6 mm being typical for municipal wastewater applications. Although hauling costs increase, the removal of more unwanted debris material at the headworks end of the WWTP considerably decreases downstream maintenances costs and prolongs the life expectancy of downstream equipment. For the Bowser WWTP, a 6 mm diameter opening size is selected as the preferred option to be consistent with today's standard. The preferred type of screen is a perforated plate screen with circular aperture, with high Screen Capture Ratio (SCR), ranging from 0.60 to 0.80.

We are proposing an auger style perforated plate screen, complete with an integral washing and compaction zone, and a bagging attachment for dewatered screenings collection. The screens will initiate a cleaning cycle when a high differential water level between the inlet and outlet channels exists. A timed cleaning cycle can also be programmed into the screen's operation should the differential water level never be reached during normal operation.

The design parameters for the screens are presented in **Table 3.1**. The screens will be designed to operate in a 1 duty, 1 standby configuration.

Table 3.1 – Fine Screen Design Data

Parameter	Design Value
Tag Numbers	SCR-01-111 and SCR-01-121
Design Flow Avg, m^3/d Peak, m^3/d	 200 795
Opening Size, mm	6
Number (Duty/Total)	1/2
Capacity, m^3/d (each)	795
Min Headloss, mm (Clean)	60
Max Headloss, mm	140
Channel Width, mm	300
Channel Depth, mm	900
Maximum Upstream Water Level, mm	440
Installation Angle, degrees	35
Screen drive motor, kW	0.75
Spray Water Requirements, L/s (@ 40 psi supply pressure)	0.40

3.2 SRS Splitter Box

As a means of equally splitting the flow to the two proposed sequencing batch reactor (SBR) tanks, a screened raw sewage (SRS) splitter box is being proposed. In addition to facilitating an equal flow split for the current design period, the box will also be designed to split the flow to future SBR tanks that may be implemented and piping will be provided to allow the splitter box to be bypassed into the SBR basins. Flow from the effluent end of the screening channels will flow into the SRS splitter box and then over weir plate into a splitting chamber. In this splitting chamber, there will be a number of weir gates corresponding to the number of SBR tanks in the process configuration. For this initial phase, there will only be two weir gates, but an allowance will be made in the structure for the installation of two future weir gates, should up to two more SBR tanks be added to the process. Flow will spill over each weir gate into a chamber and then feed pipe being directed to each SBR tank. Depending on the size of the tank, the SRS Splitter Box will also provide for a degree of flow and load equalization.

3.3 Sequencing Batch Reactor (SBR)

The SBR will be the heart of the treatment process that will be responsible for the reduction of the influent BOD and TSS concentrations to levels below that permitted by the plant's proposed operating certificate.

The SBR process is similar to conventional activated sludge, however the treatment and clarification processes take place in one reactor in a fill-and-draw system. The first step of the process is the fill cycle, where the reactor tank is filled with screened wastewater which mixes with the biomass that has settled during the previous cycle. Air is then added to the tank in the aeration cycle to aid in biological growth and biological treatment. The reactor then goes through a settle cycle where mixing and aeration stop so that solids are allowed to settle to the bottom of the tank. The length of the entire cycle normally takes four hours under normal flow conditions, or three hours during peak flow conditions. However, these cycle times are adjustable with the control system for the SBRs. The final cycle is the decant cycle where clarified effluent is discharged from the top of the reactor. **Figure 3.1** shows a process flow diagram for SBR secondary treatment.

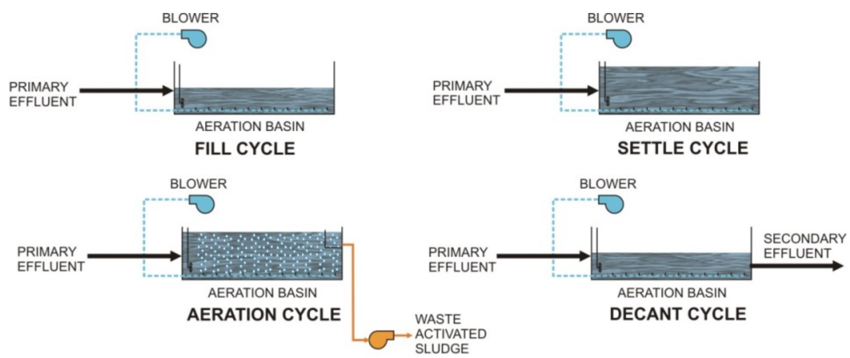


Figure 3.1 – Sequencing Batch Reactor Process Diagram

SBRs can be advantageous over conventional activated sludge reactors as their reactors normally require less space because treatment takes place in a single basin instead of multiple basins and dedicated clarifier units. Operationally, the aeration device is generally straight-forward to operate, however because of the sequencing nature of the process, the system is dependent upon automatic control to function. This is an increased level of complexity when compared to an activated sludge system. The process can handle wide variations in feed characteristics and flow rates by varying process parameters such as: mixed liquor suspended solids (MLSS), solids retention time (SRT), sludge wasting rates, sludge settling, dissolved oxygen and air flow rates. As well, the timing of the different cycles can be modified to optimize the process.

With the variant of the SBR process being proposed for the Bowser WWTP, influent is received continuously during all phases of the cycle, including settle and decant. This allows the process to be controlled on a time, rather than flow basis and ensures equal loading and flow to all tanks. Use of a time-based control system in the process facilitates simple changes to the process control program. In a flow-based conventional SBR, cycle times and individual segments of each cycle may be different among basins due to diurnal flow variations. Thus, it is not possible to simply affect a change to the entire system. In essence, separate control must be maintained over each basin in the SBR system.

Single tank operation is also possible in this proposed process configuration. The process does not require automatic influent control valves or an additional tank to hold diverted flow. This eliminates the need for designated fill and idle phases resulting in smaller tanks. This also helps to meet the reliability requirements outlined in the BC Municipal Wastewater Regulations (process must be capable of treating 75% of the design flow with the largest unit out of service).

Each SBR tank is divided into two zones, the pre-react zone and the main react zone. A non-hydrostatic baffle wall with openings at the bottom is constructed to divide the SBR tank into the two zones. The influent flows continuously into the pre-react zone and is directed down through engineered orifice openings at the bottom of the baffle wall into the main react zone. The pre-react wall baffles the incoming flow and prevents short-circuiting. The volume of the pre-react zone is typically 10 to 15 percent of the total tank volume. We are proposing to make an allowance for the installation of submersible mixer in the pre-react zone to allow for future process flexibility should a permit requirement be necessary for ammonia or total nitrogen reduction.

Table 3.2 outlines the various design parameters for the continuous flow SBR process that is being proposed for the Bowser WWTP.

Table 3.2 – Continuous Flow SBR Design Data

Parameter	Design Value
SBR Tanks	
Tag Numbers	T-02-110 and T-02-120
Volume, m^3	113
SWD, m	4.4
Freeboard, m	0.6
Decanters	
Tag Numbers	DEC-02-114 and DEC-02-124
Weir Length, m	0.9
Motor, kW	0.19
Decant Rate (AAF), m^3/min	0.8
Decant Rate (PHF), m^3/min	1.2
WAS Pumps	
Tag Numbers	P-02-115 and P-02-125
Type	Submersible
Flow Rate, L/min	420
TDH, m	4.0
Motor, kW	2.2

3.3.1 Process Air System

The process air system will fulfill two main functions: (1) supply of process air to the SBRs; and (2) supply of mixing air to the Aerated Sludge Tank. The blowers will be housed in the Blower Room of the Operations Building and a space allowance will be made for a future added blower. As SBRs have varying water levels, they impose a varying static head on the blowers' discharge. For this reason, positive displacement (PD) blowers have been selected to supply process air as they can vary their output based on discharge pressure. PD blowers also offer an economical choice when smaller blowers (< 25 kW) are required.

Table 3.3 outlines the design parameters for the process air blowers.

Table 3.3 – Process Air Blowers' Design Data

Parameter	Design Value
Tag Numbers	BL-02-132, BL-02-133 and BL-02-134
Duty/Total Units	2/3
Capacity, am^3/min	4.0
Discharge Pressure, kPa	51
Motor, kW	7.5

The process air blowers will deliver air to the respective SBRs when they are in an aeration cycle. The blowers will be equipped with variable frequency drives (VFDs), which will be controlled by dissolved oxygen probes in the SBR basins and mass flow meters on the main air distribution lines.

Fine bubble flexible membrane diffusers will be installed in both SBR basins to facilitate the transfer of process air from the blowers to the mixed liquor. The flexible membrane material will be Ethylene Propylene Diene Monomer (EPDM) and the diameter of each diffuser will be 225 mm at a submergence depth of 4.1 metres. The aeration configuration for the Aerated Sludge Tank will be discussed further in Section 3.5 of this report.

3.4 Odour Control

A vendor supplied carbon scrubber is included in the design for the plant headworks and the screened raw sewage splitter box.

3.5 Secondary Effluent Pumping & UV Disinfection

3.5.1 Secondary Effluent Pumping

The challenge with incorporating UV disinfection with an SBR process is the intermittent discharge of secondary effluent from the SBR basin. In a UV disinfection process the lamps rely on the continuous flow of secondary effluent for cooling. Without the cooling, the lamp life is significantly diminished and process risks failure. As each of the two SBR basins combined only decants/discharges secondary effluent for a maximum of 50% of the full cycle time, there is another 50% of the time where there is no discharge of secondary effluent to the disinfection process. A way to alleviate this is to utilize a secondary effluent (SE) equalization tank complete with SE pumps.

It is proposed that an SE Equalization Tank be placed immediately downstream of the SBRs and be fitted with two submersible well pumps arranged in a horizontal configuration. These pumps will pump SE on a continuous basis to the inlet of the UV channel. The pumps will also be on variable frequency drives (VFDs) to maintain a continuous flow while not draining the SE Equalization Tank too low. An ultrasonic level sensor (LE-03-111) in the SE Equalization Tank will be used to control the duty pump's speed.

Table 3.4 outlines the design parameters for the secondary effluent pumps.

Table 3.4 – SE Pumps' Design Data

Parameter	Design Value
Tag Numbers	P-03-112 and P-03-113
Type	Submersible Well Pump – Horizontal
Duty/Total	1/2
Flow Rate, L/s	10
TDH, m	5.0
Motor, kW	TBD

3.5.2 UV Disinfection

Ultraviolet light achieves disinfection by inducing photobiochemical changes within microorganisms. To achieve an effective photobiochemical reaction, radiation of sufficient energy to alter chemical bonds must be available and the radiation must be absorbed by the particular molecule. For wastewater applications, low pressure mercury lamps are typically utilized. These systems produce monochromatic UV light with 85% of the wavelengths at 253.7nm. Research has shown that nucleic acids strongly absorb radiation between 240 and 260nm. As a result, radiation at 253.7nm has been shown to have good anti-microbial properties.

The most important wastewater characteristic that influences UV disinfection is UV transmissivity (UVT), which is a measure of the "transparency" of the wastewater to the passage of UV light. Other wastewater characteristics that influence UV disinfection include iron concentration, complex soluble organics, water hardness, total suspended solids (TSS), turbidity, and particle size distribution. The TSS concentration determines in part the effectiveness of the UV disinfection, as suspended particles shield organisms from the disinfection properties of the UV light.

The Municipal Wastewater Regulation (MWR) requires that the UV disinfection system be designed such that if one unit is out of service, the remaining units can provide 75% of the design flow capacity. The UV disinfection system will be installed in stainless steel or concrete channels located downstream of the SE Equalization Tank. The UV system will consist of two UV banks in series. The system will be sized such that one bank can provide 75% of the peak hour flow. This will meet the MWR requirements for reliability and allow for one unit to be offline for repairs or maintenance. Consideration will also be given to the addition of a bypass channel should expansion in the future be required and to facilitate maintenance of the current configuration.

To provide for complete disinfection of the effluent flow, the water level in the channel cannot fluctuate appreciably. If the water level rises more than 50 mm above the top bulb, there is a risk that the water stream near the surface will not have adequate contact with the UV radiation. For simplicity and robustness, a fixed weir will be used to control the water level in the UV channel.

The UV system will also include an automated cleaning system. Maintenance should be limited to regular monitoring of the bulb and ballast status and replacement, as necessary.

The design parameters for the UV disinfection system are presented in **Table 3.5**

Table 3.5 – UV Disinfection Design Data

Parameter	Design Value
Peak Capacity, L/s	9.2
Minimum UVT transmittance, %	50
Maximum TSS, mg/L	25
Fecal Coliform, MPN/100 mL	200
Design UV dose, mWs/cm^2	60 to 90
Number of UV channels	1
Number of banks per channel	2 (1 duty)
Number of UV lamps per bank	4
Total number of UV lamps	8
Water Elevation Control	Serpentine or Finger Weir
Channel width, mm	250 to 300
Channel depth, mm	500 to 750

3.6 Waste Secondary Solids Storage

An onsite waste secondary solids storage/aerated sludge tank will be provided to store the residual stream generated by the SBR process before it is hauled off-site to the French Creek Pollution Control Centre (FCPCC) for further processing.

The Aerated Sludge Tank will be aerated with a coarse bubble aeration system to mix the contents of the tank prior to pumping it out. The process air for this system will be taken from the main process air header located at the outlet of the Blower Room. The overall tank size is equal to each of the SBR tank sizes, which will allow for its conversion to SBR #3 in the future, should it be required. For sludge storage, the tank will be divided into two cells to allow for maintenance on one cell as necessary. It is also likely that only one cell will be used given that a single cell will provide over ten days of storage under maximum design loading conditions in the summer.

The design parameters for the sludge storage tank are presented in **Table 3.6**

Table 3.6 – Aerated Sludge Tank Design Criteria

Parameter	Design Value
Number of Cells, Total/duty	2/1
Maximum Day WAS production, m^3/d	5
Storage Volume Per Cell, m^3	53
Minimum Retention Time, days	10.6
Aeration Requirements	
Type of Aerators	Coarse Bubble Duckbill Valve
Air Mixing Requirements, $m^3/m^3/min$	0.04
Air Flow/Cell, m^3/min	2.2
Number of Aerators	TBD

4.0 CIVIL DESIGN

The civil design described in this section only relates to the site aspects of the wastewater treatment plant design. The design aspects for the collection system are described separately in the document entitled, *Bowser Sanitary Sewer Pre-Design Concept* (Appendix A).

4.1 Plant Elevation

The new process tankage will be designed to be at an elevation that is 1000mm above grade. A freeboard depth of 0.6 metres under peak hydraulic flows will be used as a design standard. Main floor elevation of the treatment plant building will be set at approximately 49.000m geodetic.

4.2 Access Roads

The proposed treatment plant location is approximately 0.5km from Highway 19A. A proposed 7.0m wide gravel access road will need to be constructed from the intersection of Highway 19A and Sundry Road to the site complete with 0.5m shoulders and ditches for drainage. Maximum slope of the road will be 6.0%

4.3 Site Grading, Drainage

The site will be graded to provide positive drainage away from all process tankage and the building. No curbs or catchbasins are proposed for the site as the stormwater can be sheeted off to overland flow. Maximum slopes on the paved surfaces surrounding the plant will be 2.0%.

4.4 Electrical Service

Electrical feeds to all new areas will be run in underground duct banks. Where appropriate and required by code, these duct banks will be encased in concrete. A pad mounted transformer has been located at the WWTP site in the boulevard area west of the electrical room. A 250 kVa hydro service is expected to be overhead to this location from Highway 19A and will need to be coordinated with BC Hydro. The electrical estimate includes an allowance for the hydro service.

4.5 Domestic Water Supply

The estimated daily requirements for domestic water will be less than 10,000 litres and likely a rate of less than 8 litres per minute.

5.0 ARCHITECTURAL DESIGN

5.1 Design Criteria

The proposed building is a single storey stand-alone structure that contains the process and mechanical/electrical equipment, along with a control room / administration area. The proposed building will be situated amongst the tanks associated with wastewater treatment process. The building will be of non-combustible and combustible materials as required to meet code and service requirements.

5.2 Building Construction

The occupancy of the building will be Group F, Division 3, Low-Hazard Industrial. The entire building will be under one tenancy and will face at least one street.

Building Area (gross):	Approx. 238m2
Building Height:	1 Storey
Building Construction:	Combustible and Non-combustible
Fire Sprinklers:	No

The building will comply with 3.2.2.78 Group F, Division 3, up to 2 Storeys (Group D has the same restrictive requirements as Group F, Division 3. – see 3.2.2.55, Group D, up to 2 Storeys).

Building Area:	Max 800m2 facing one street
Building Height:	2 Storeys
Building Construction:	Combustible and Non-combustible
Fire Sprinklers:	No
Floor Assemblies:	Fire Separation (if combustible construction shall have 45 min Fire Resistance Rating (FRR)

Loadbearing walls, columns and arches supporting an assembly are required to have a FRR of not less than 45 minutes or be of non-combustible construction.

5.3 Spatial Exposures

The spatial separations on all sides of the building are sufficient to allow unprotected openings, as there are no neighbouring buildings.

5.4 Fire Separations

Fire separations and fire resistance ratings are required at the following locations:

Table 5.1 – Fire Separation Ratings

Location	Fire Resistance Rating
Electrical Room – Main Floor	One hour fire separation
Exit Corridor	45 min fire separation

Supporting structures for fire separations or assemblies required to have a fire resistance rating are also required to have an equal fire resistance rating.

5.5 Exits

At least two exits are required from the building. The maximum permitted travel distance to one of two exits is 30m. More than the 2 exits as required have been shown on the drawings. The maximum travel distance proposed for the building is less than 30m.

Exit width is sufficient for the occupant loads proposed for this site.

5.6 Water Closets

The occupant load for the entire building, as a whole, will be less than 10 people, therefore, as per B.C.B.C.3.7.2.2 (4); one water closet serving both sexes is permitted. The unisex washroom including shower is located within the building adjacent to the lab/office/control room area.

5.7 Fire Sprinklers

A fire sprinkler system and hose valves are not required.

5.8 Fire Alarm System

A fire alarm system is not required by Code; however it may be included in the scope of work at the discretion of the RDN.

5.9 Safety

The SBR, sludge holding tank and equalization tank are approximately 5 metres deep. The RDN operators and contractors will from time to time be required to access the bottom of these tanks to perform functions that include maintaining equipment, equipment retrieval and tank cleaning. The RDN will need to, as a minimum, employ policies and procedures for Confined Space Entry, Hoisting and Lifting and use of Portable Ladders. The policies and procedures to perform these functions must be conducted by trained, qualified, competent, and authorized employees and contractors.

6.0 STRUCTURAL DESIGN

6.1 Introduction

The new structures for Bowser WWTP must be designed to meet the many unique challenges that are associated with the processes involved as well as with the particular site. The following sections describe the proposed design criteria that will be used, and summarize the proposed structural concepts for each major component of the facility.

6.2 Below Grade Structures

The Bowser WWTP will include a number of below or partially below grade facilities including:

1. An Operations Building containing screening channels;
2. An influent splitter box;
3. Two sequencing batch reactors (SBRs);
4. Effluent equalization tank;
5. UV disinfection channels; and
6. Aerated sludge storage tank.

All of these below grade structure must be designed with consideration of the geotechnical conditions at the site. The preliminary assessment of the soils does not indicate a high water table, therefore structures should not have to be designed to counteract the buoyant forces or be provided with pressure relief valves to prevent flotation when tanks are dewatered for maintenance. Shoring and/or dewatering will likewise not be required for any underground structures. The potential for excavation base heave due to artesian conditions should be assessed for each of the major excavation areas following completion of a detailed test drilling program and geotechnical investigation at the location of the below grade structures.

6.3 Building

The Operations Building is planned to be a single storey, slab on grade building. The building will house some process functions, as well as an electrical room, mechanical room and a control room. Materials for new building construction for the proposed works should be durable and provide for low maintenance. Where possible, energy efficient building envelopes should be selected to reduce building operational costs. Split face masonry walls are suggested to be designed and detailed for this building, with a possible architectural treatment to allow it blend into the surrounding area.

6.4 Design Criteria

The structures will be designed in accordance with the following codes:

- British Columbia Building Code 2012;
- NBC 2010;
- ACI 350M-06 "Code Requirements for Environmental Engineering Concrete Structures";
- ACI 350.3-06 "Seismic Design for Liquid-Containing Concrete Structures"; and
- All applicable CSA Standards.

The new structures will be designed as post-disaster structures. The design loading criteria will be as follows:

Ground Snow Load: Ssnow = 1.3 kPa, Srain = 0.1 kPa and Is = 1.25;

Seismic Load: Sa (0.2) = 0.302, Sa (0.5) = 0.234, Sa (1.0) = 0.147, Sa (2) = 0.084;

Peak Ground Acceleration, PGA = 0.151;

Earthquake Important Factor, I.e. = 1.5;

Wind Load:

a. q50 =0.59 kPa for all structural members and cladding
b. q10 =0.40 kPa for others
c. Iw =1.25

Floor Live Loads:

a. Lobbies, corridors and aisles = 4.8 kPa
b. Workshop = 3.6 kPa
c. Process equipment spaces = Equipment weight or 4.8 kPa, whichever governs

Durability of concrete can be achieved by using high quality concrete with a minimum compressive strength of 32 MPa at 28 days and an exposure class of F1. To minimize concrete shrinkage cracks caused by thermal shocks, 20% flyash will be specified in concrete mix design to slow down the rate of hydration during concrete initial curing.

All water retaining structures will be designed in accordance with ACI 350M, complete with amount of reinforcing no less than the minimum shrinkage and temperature reinforcement as required by ACI 350M. Control and/or construction joints will also be utilized at critical locations to minimize concrete cracks caused by temperature differential related volume changes. These joints will be incorporated with PVC water-stop and sealant to prevent leakage.

For economy and practical reasons, standard uncoated deformed reinforcing steel bars will be used for all concrete structures. A minimum of 50 mm concrete cover will be specified to protect the re-bars from corrosion. In the screening channels, consideration should be given to coating the concrete with a protective coating as the existing concrete upstream of the plant has experienced degradation.

6.5 Material Specification

Material Specifications for the new facility can be summarized as follows:

- Structural steel: to CAN/CSA-G40.21M, grade 350W
- Anchor bolts embedded in concrete: to ASTM A307
- Bolts: to ASTM A325
- Welding: to CSA W59, fabricator certified to CSA W47.1, Div. 1 or 2.1;
- Fabricate steel members to in accordance to CSA S16.1 and S136;
- Shop Primer: to CAN/CGSB 1-GP-40 or CISC/CPMA 2-75;
- Galvanizing: to CAN/CSA-G164, minimum 600 gm/sq.m. ;
- Cement: General Use Hydraulic Cement, Type GU with 20% Flyash ;
- Concrete: 32 MPa minimum compressive strength at 28 days with 5 to 8% air content;
- Reinforcing Steel: deformed steel bars to CSA G30.18M, grade 400; and
- Concrete Block Unit: to CSA CAN3-A165 classification H/15/A/M with type S mortar;

6.6 Geotechnical Conditions

A preliminary soil assessment was undertaken as part of a site reconnaissance undertaken by WSP in December 2015. The preliminary Geotechnical Investigation Report is provided in Appendix c.

Observations indicate that the site is in a forested area, with fairly thick undergrowth. The ground surface was found to be generally level, with a slight slope to the north and northeast.

WildCat Penetrometer testing was done at three locations on the site (two at the property's south end and one at the north end). For all three, the tests extended to depths ranging between 0.7 and 1.1 metres. This interface was interpreted to be the beginning of a dense layer of silt till. This also coincided with observations of a ditch on the adjacent property, which showed glacial till at exposed areas.

A desktop review of local well water logs in the local area was also undertaken. These logs have indicated that till soils extend to depths of more than 50 metres. Under the conditions noted in the 2012 BC Building Code, the treatment plant site would therefore be considered a seismic Site Class C. Based on this and the preliminary geotechnical assessment, an allowable bearing capacity for the Operations Building's slab and below ground tank footings would be approximately 250 kPa.

The Geotechnical investigation for the wastewater treatment plant site was limited to the perimeter of the site on an adjacent property as there was no practical vehicle assess. Interpretation of the investigation has indicated that the proposed treatment plant site is underlain by shallow competent glacier fill soil that could be expected to provide suitable bearing support for the treatment plant building and associated equipment.

7.0 BUILDING MECHANICAL DESIGN

7.1 Introduction

The purpose of this section is to describe the design criteria and function of the building mechanical systems that form the scope of the new Bowser Wastewater Treatment Plant. This section is intended to form the basis for detailed design of the required HVAC, plumbing, fire protection, and HVAC control system and provide enough information for the client and third parties to understand the building mechanical systems, and to allow the design team to coordinate building mechanical systems with the structure and architectural features.

Listed are the various rooms for which HVAC systems are designed to provide acceptable room conditions and low energy use while maintaining the needs of specific occupancy.

- Screening Room
- Electrical Room
- Mechanical Room
- Process Air Blower Room
- Washroom
- Lab/Office/Control Room

The mechanical system for each room will be designed in accordance with the current edition of the following codes, standards and references:

- 2012 British Columbia Building Code
- 2012 British Columbia Plumbing Code
- NFPA 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities, 2012 edition
- NFPA Standard 45
- CSA Cross Connection Control Standard (for domestic water service piping) CAN/CSA-B64.10-11
- National Energy Code of Canada for Buildings 2011 Edition (NECB)
- B.C. Power Engineers Boiler, Pressure Vessel and Refrigeration Regulations (if applicable)
- CAN/CSA B149.1, Natural Gas and Propane Installation Code (if applicable)
- NFPA 13, latest edition (if sprinklers are applicable)

- NFPA 10, latest edition (fire extinguishers)
- Worksafe BC Standards
- SMACNA Duct Construction Methods
- SMACNA Seismic Restraints Standards
- ASHRAE 62-2013
- ASHRAE 90.1-2010
- American Industrial Hygiene Association (AIHA) Standard Z9.5
- MD 15128 Minimum Guidelines for Laboratory Fume Hoods

7.2 HVAC Design Conditions

7.2.1 Outdoor Design Conditions

The design of the HVAC system will be based on an ambient outdoor temperature range of -10°C to +35°C.

7.2.2 Indoor Design Conditions

The inside design conditions may vary depending on the area being served and the frequency of occupancy. The Screening Room contains occasionally uncovered influent channels. The plant influent provides an excellent heat sink, and consequently it is very energy intensive to raise the inside air temperature more than a few degrees beyond the plant influent temperature. The plant influent temperature varies between 12°C to 20°C depending on the season and the winter indoor air temperature should be no less than 12°C for areas supplied with heated outdoor air and/or space heating. In order to control indoor humidity it is advantageous to keep the indoor air temperature 2°C above the plant effluent temperature in order to limit evaporation and thus control humidity.

7.2.3 Ventilation Requirements

The HVAC design conditions and ventilation rates for the building rooms are presented in **Table 7.1**.

Ventilation for the process areas will be as per NFPA 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities. Ventilation for the other areas will be as per ASHRAE ANSI/ASHRAE 62.1-2004, Ventilation for Acceptable Indoor Quality.

Table 7-1 – HVAC Design Requirements

Room	Design Indoor Temp		Ventilation Rate Air Changes / hour	Hazardous Classification	Room Pressure
	Max Summer (^{o}C)	Min Winter (^{o}C)		Classified or Unclassified	Positive, Negative, or Neutral
Screening Room	N/A	12	12/6	Classified	Negative
Electrical Room	30	15	N/A	Unclassified	Neutral
Mechanical Room	30	15	6	Unclassified	Neutral
Control Room/Office/Lab	24	22	2 or 20 CFM/person	Unclassified	Neutral
Laboratory Fume Hood	24	22	8/4	Unclassified	Negative
Washroom	N/A	22	6	Unclassified	Negative
Blower Room	30	12	N/A	Unclassified	Neutral

Air handling units (where required) will be installed in the specific rooms listed with exception of the Blower Room. For the Blower Room equipment will be installed on the roof. Ventilation rates for the Screening Room will consist of 100 % outside air.

7.2.4 Classification Definitions

In accordance with NFPA-820 and NEC/NFPA-70 the classification designations are:

- Class 1/ Division 1 & Class 1/ Division 2 per article 500 of NFPA-70/NEC (explosion containing electrical enclosures), with fan systems required to AMCA 'A' or 'B' rated with explosion proof electric motors (TEXP type). Note AMCA 'A' or 'B' ratings requires non-sparkling (non-ferrous) fan/ventilation system construction. 'A' rated requires ferrous (iron) bearings be placed out of the air stream, while a 'B' rated fan can be non-sparkling construction with bearings in the air stream.
- Unclassified per NFPA-820 (not NEC 1/ Division 1 & Class 1/ Division 2), meaning that special electrical and fan systems are not required, provided the space is ventilated to a minimum standard as noted in NFPA-820.
- Spaces/buildings not listed in Chapters 4, 5, 6 in NFPA-820 are not governed by NFPA-820, and therefore shall follow the ASHRAE/BCBC standards.

7.2.5 Air Filtration System

Total filtration efficiency of MERV 8 [ASHRAE 52.2-1999]—25-30% average efficiency when evaluated against ASHRAE Standard 52.1-1992—will be designed for all areas.

It is not anticipated that any of the exhaust air systems will require scrubbing treatment on the discharge.

7.2.6 Noise Control System

Noise control measures are assumed to be minimal. All rooftop equipment will be positioned to mitigate noise transfer to the surrounding neighbourhood area.

7.2.7 Humidity Control

No relative humidity control will be provided.

7.3 HVAC Systems

7.3.1 Screening Room

A 100% outdoor air supply and exhaust air heat recovery air handling unit will be used for the screening room heating and ventilation.

The custom air handling unit will be an indoor pre-manufactured, explosion proof unit located in the Mechanical Room. It is equipped with two single-speed supply fans (each 50% capacity), two single-speed exhaust fans (each 50% capacity), a heat recovery plate with motorized bypass dampers, an electric final heating coil, and a remote control panel. Exhaust air will be directed to either a foul air treatment system or to atmosphere via a common exhaust system.

A set of fans will provide a total of 6 AC/h whenever the supply air temperature is 10ºC or less; or whenever combustible gas detectors show acceptable lower flammable limit. Both sets of fans will run and provide a total of 12 AC/h whenever the supply air temperature is above 10ºC; whenever the ventilated space is occupied; or, whenever fans are activated by combustible gas detectors set to function at 10 percent of the lower flammable limit.

All ductwork serving the screening room will be Stainless 316L with welded joints.

7.3.2 Mechanical Room, Washroom and Control Room

The Mechanical Room, Washroom and Control Room will be heated by means of electric baseboard or radiant heaters. Filtered outdoor air intake provides the air supply to the rooms and an exhaust fan ventilates the rooms.

7.3.3 Laboratory

An induced flow, high plume exhaust fan is provided for the laboratory fume hood. The exhaust fan is connected to the fume hood and exhaust air is vented via a stack located on the roof of the building.

As per the American Industrial Hygiene Association (AIHA) Standard Z9.5, the minimum stack height should be 3 m above the adjacent roof line, with an exhaust velocity of 15 m/s, and stack height extended one stack diameter above any architectural screen. The National Fire Protection Association (NFPA) standard specifies a minimum stack height of 3 m to protect roof-top workers. Regulations for toxic chemical emissions will be in accordance with federal, provincial and local air quality agencies guidelines and standards.

7.4 Controls

The mechanical systems will be controlled, monitored and alarmed using a standard direct digital control (DDC) system.

7.5 Utilities

7.5.1 Natural Gas Service

Given the proximity of the distribution system, natural gas service to the site may not be economical and is not currently being considered.

7.5.2 Water Service

A 100mm water service is required for the WWTP. The new service will connect to the Bowser Water Works system at the intersection of Highway 19A and Sundry Road.

7.5.3 Sanitary Service

The building sanitary collection system will convey wastewater to a sump pump which will discharge to the raw sewage influent channel. The sump pump will also be connected to floor drains and process drains.

7.5.4 Storm Drainage

Storm drainage from the building and paved areas will be collected and discharged to one or more dry wells, as required.

7.5.5 Foundation Drainage

New perimeter footing drainage will be provided if required based on the geotechnical report requirements.

7.5.6 Irrigation

None will be provided.

7.6 Plumbing System

7.6.1 Storm Drainage Systems

New roof drains will be installed to suit roof slopes. The rain water leaders from the roof drains will be routed to the storm drainage dry wells.

7.6.2 Sanitary Drainage Systems

A drainage system consisting of cast iron drain piping with mechanical joints and copper vent piping with soldered joints will be installed to serve all plumbing fixtures. The cast iron drain piping would provide the best acoustic performance, as well as being durable.

The vent piping system will be connected and routed to the roof, located away from any windows and air intakes.

7.6.3 Domestic Water Supply System

A system of domestic hot water, cold water and domestic hot water recirculation piping will be provided, to serve the laboratory, control room, screens and washrooms. The new piping will consist of insulated type K copper tubing with soldered joints, sized in accordance with BCBC requirements / standards.

All of the domestic hot water will be supplied from the central domestic hot water storage tank. Domestic hot water will be reheated by electric heaters. A single recirculation pump in the Mechanical Room will constantly circulate the domestic hot water for temperature maintenance.

An emergency eyewash will be provided in the lab. Should the owner's hazard assessment find that an emergency shower is also required, then one will be provided.

7.7 Fire Protection

7.7.1 Fire Suppression/Protection System

It is anticipated that the structures proposed for this project will not require sprinkler fire protection.

Fire extinguishers will be located as required by NFPA 10, and/or as directed by the local Fire Authority.

8.0 ELECTRICAL DESIGN

8.1 Introduction

The electrical loads for the plant will be fed from a motor control centre (MCC) installed in the electrical room. Due to the relatively small service size, a pole mount customer service from BC Hydro is expected. Once the electrical loads are finalized, the demand calculation will be updated and arrangements made with BC Hydro.

8.2 Applicable Codes and Standards

The electrical design and system features will be selected based on the latest editions of all applicable Federal, Provincial and local Municipal codes; and the functional and environmental requirements of the facility through effective lighting, power and control systems design.

8.3 Electrical Loads

Electrical switches, gear, and motor control centers (MCC) will be required to support the electrical loads and equipment for the new WWTP. The intention is that all equipment added will use only high efficient motors suitable for the specific process applications.

The MCCs and room spaces will be designed with enough capacity to accommodate the current and future electrical loads. The MCC will have a main circuit breaker sized for all new and future loads, power monitor and Surge Protective Device (SPD).

Process and HVAC loads with motors and fractional horsepower (hp) motors up to ½ hp will be powered by 120/208 VAC, 60 Hz, 1 phase power. Motors between ½ hp and ¾ hp will be powered by 120/208 VAC, 60 Hz, 3 phase power. Motors equal to or larger than 1 hp will be powered by 600 VAC, 60 Hz, 3-phase from the main MCC.

Each motor starter will have either Local-Off-Remote or On-Off control, and local control with remote capability for system control through the plant control system (PCS).

The MCC will be used for all process loads and major HVAC equipment. The MCC will be EEMAC Class 2, Type C with copper bussing, vertically stacked with a control terminal section located in each starter. Variable Frequency Drives (VFDs) will be installed for the motors associated with some of the pieces of process equipment. Variable Frequency Drives (VFDs) will comply with IEEE 519 for harmonic distortion requirements. All variable speed drives will be equipped with minimum 3% line reactors, and 5% load reactors. The MCC supplied will be an intelligent MCC with the built-in Profibus DP network and all VFDs, contactors and power monitor will communicate to the PCS through the Profibus DP network.

8.4 Grounding

The design includes grounding systems for all equipment to:

1. ensure stable system voltage reference; and
2. ensure limitation of over-voltages, switching surges, ground faults and other conditions.

This will enable proper operation of circuit protective devices by providing a low impedance path for the fault current. The grounding system will ensure personnel and equipment safety, as well as proper equipment operation.

Grounding systems for the MCC, control panels, distribution panel boards, dry transformers, and instrumentation bus will be connected to the main grounding bus for the treatment plant.

8.5 Facility Lighting

The following summarizes the lighting design and lighting systems to be implemented for the proposed upgrades:

- Lighting systems will be designed as energy efficient, quality artificial lighting systems determined by analysis of alternate designs incorporating an appropriate effective recurring lighting maintenance program. Energy consumption will meet or exceed ASHRAE 90.1-2001;
- Lighting design will be in accordance with the IESNA lighting handbook;
- The design includes luminaries in all electrical/control rooms, corridors, and process areas. Luminaires will include linear fluorescent and HID systems for process and exterior areas;
- All luminaires will be suitable for the environment where they are located;
- Lighting control systems for exterior fixtures will include a contactor from an “On Off Auto” switch and photocell control;
- Emergency battery packs and remote heads will be provided for immediate illumination in areas of emergency egress, electrical rooms and process mechanical equipment rooms and areas to illuminate evacuation routes during emergency conditions or power outages until the standby power is activated. All units will be sized for half hour emergency operation; and
- Exit signs will be LED type with “EXIT” written in 150mm high red lettering on white background and with removable directional arrows. Exit lights will be connected to AC power with all breakers feeding these devices in the locked on position.

The general use spaces and individual areas, which are generally separated from adjacent occupancies by walls, are individually illuminated to the recommended IES lighting levels. The design levels for lighting in LUX (maintained average) will be:

- Control Room / Laboratory Space 550Lx
- Corridors 200 Lx
- Equipment / Maintenance Room 250-300 Lx
- Mechanical and Electrical rooms 250 Lx
- Process Areas 300 Lx

8.6 Wiring Methods and Equipment

All feeders will consist of copper conductors pulled in conduits, with separate grounding conductors for interior distribution equipment and TECK90 armoured cable for process and exterior feeders. To ensure the quality of power distribution, and to compensate for voltage transients that can occur on site, a SPD will be installed at the MCC distribution. All TECK90 cables will either be installed in the cable trays or in the underground duct banks.

All interior HVAC power feeders, lighting and line voltage control conductors will be run in conduit raceways or cable trays. Rigid steel conduit will be used where susceptible to damage, or in wet or hazardous locations. Different voltages shall each be racked at different elevations.

All wiring will be RW90XLPE copper. The minimum size of wire for lighting and HVAC loads will be No. 12 AWG and No.14 AWG for control. Conductors for lighting and miscellaneous power wiring will be colour coded. The minimum conduit size will be 19 mm.

All wiring and equipment installed or operated within any of the Class 1, Zone 2 locations (defined in Sections 18 and 20 of the Canadian Electrical Code) will comply with applicable provisions of Section 18 of the Canadian Electrical Code. Electrical systems will be designed in accordance with NFPA 820 provisions.

All underground wiring will be installed in PVC conduits with termination fittings approved for the location. In process areas and areas exposed to mechanical damage conduits will be rigid galvanized steel.

8.7 Standby Power

Critical electrical loads within the new facilities will be powered in the event of a utility power failure. A standby generator c/w Automatic Transfer Switch (ATS) will be provided. The size of the generator is 180 kW and the ATS will be rated for 180 Amps at 600VAC.

9.0 INSTRUMENTATION & CONTROLS DESIGN

9.1 Introduction

This section contains the instrumentation and control design information for the new WWTP. It also outlines some of the general concepts for design of the Plant Control System (PCS) — utilizing technology that is reliable, field proven and integrates with existing RDN control systems.

9.2 Process Control Philosophy

The various unit processes will be controlled by Programmable Logic Controllers (PLC). The PLCs and PCS computers will be powered from an UPS to maintain data integrity. The main Local Control Panel (LCP) will be installed in the new electrical room and will house the main PLC and the automatic alarm dialer. Most process equipment, such as headworks fine screens, SBR system and UV disinfection process, will come with their own local control panels with integral PLCs.

A PCS computer will be provided and installed in the Control Room. One more computer will be provided and will be used as an engineering station to be used for PLC programming and DeviceNet network and equipment monitoring.

The new plant control system will be based on the Schneider Quantum PLC series. The PLC CPU operating system will be Unity and the latest version of the Unity Software will be provided to the RDN at the end of the project. The number of the Quantum PLCs will be determined during the design. The process equipment supplied controlled by their own PLC equipment will be based on Schneider M340 series of the PLCs. The communication between the PLCs will be based on Modbus TCP Ethernet protocol. If the process equipment is supplied with Operator Interface Panels (OIP) they will be Schneider Magelis 12.1'" colour touchscreen panels with a built in Ethernet Port.

The new PCS software for the plant will be Wonderware inTouch (the latest version). We will design a server/client based system with two PCS computers located in the Control Room. They will run in a hot standby arrangement which will ensure that the PCS system runs in case of one computer failure.

9.3 Process Control Modes

The following control modes will be employed:

- All individual process equipment and packaged process units will have Automatic and Manual control modes, selectable by the operator; and
- All process equipment or packaged process units, such as aeration blowers, will be controlled by a "maintained control mode". Contact 'close' will cause the equipment to operate and contact 'open' will cause the respective equipment to stop.

Pumps, blowers and exhaust fans will be run from Variable Frequency Drives and FVNR starters installed in the MCC. Each VFD or starter will be supplied with a hard-wired Remote Operator Station (ROS). A Local-Off-Remote switch with Run and fault indication lights will be installed at each ROS with an E-Stop push button if applicable.

In the 'Local' position, manual control of the equipment will be activated. These control devices will be grouped as a remote control panel/station for individual equipment.

In the 'Remote' position, the PLC will control the operation and sequencing of the process equipment.

Each electrical motor will be supplied with the following functions as part of its control system (communication to the plant control system through Ethernet):

- Run permissive to indicate to the control system that it can run in 'Auto' mode;
- Run status;
- Process interlocks;
- Alarms and Faults;
- Electrical Motor Current;
- Motor speed (for VFD driven motors);
- Local-Off-Remote in 'Remote';
- If emergency shut-down (ESD) is provided on the packaged unit, then provisions shall be made for additional ESD remotely mounted on the process floor. Status of the ESD will be monitored by the PLC; and
- The pumps, blowers and exhaust fans will automatically restart after power failure and power restoration if that is part of an automatic restart-after-power-failure routine.

9.4 Process Alarms

All process alarms will be wired in fail-safe mode. 'Open contact' will indicate an alarm condition; 'Closed contact' will indicate a normal condition.

All alarms will be shown and logged on the plant control system.

9.5 Process Interlocks

All process interlocks will be wired into the PLC. The PLC will determine the correct process control action based on the status of the interlock.

9.6 Safety Interlocks

Two types of safety interlocks have been identified:

Equipment safety - protects process equipment against unusual process conditions. A typical equipment safety interlock would be 'level low low' to prevent a pump from running dry. All equipment safety interlocks will be wired into the PLC. The PLC will then determine the correct equipment shut down action or will prevent the equipment start.

Personnel safety - protects personnel against injury. A typical personnel safety interlock is 'Emergency Shutdown Device' (ESD). The personnel safety interlock will be hard wired to a properly selected point or points in the control system to immediately shut down the process in case of emergency. The ESD will bypass the PLC based control system and will either completely de-energize the process equipment or will cause the equipment to come to a full stop regardless of any process condition. Emergency stop push buttons or pull strings will be strategically located in process areas and by exit doors from process rooms.

9.7 Facilities Control Panels

The main control function of the facility is based on a PLC-based supervisory control system with local control panels (LCP) to facilitate the complete control and monitoring of the facility in accordance with the process requirements.

All PLC components and I/O modules will be sized to provide sufficient capacity to handle the logic and data requirements plus an additional 50% spare CPU and memory.

Each PLC control panel shall be equipped with an Ethernet switch with fibre and Cat5 connection ports.

Expansion modules I/O signal voltage/parameters will be based on the following:

- Digital inputs and outputs: 120 VAC, quantity to be determined at final design. All digital output modules are to be based on isolated contact type for each individual point. Digital input modules shall be isolated and non-isolated types to meet the I/O circuit requirements.
- Analog inputs and outputs: 4-20 mA, 24 Vdc; quantity to be determined at final design. All analog modules shall be based on 4-20 mA dc isolated type.

The following Quantum PLC hardware shall be used:

- Power Supply: 140 CPS 114 20
- CPU: 140 CPU 323 12U
- Digital Inputs: 140 DAI 540 00
- Digital Outputs: 140 DRA 840 00
- Analog Inputs: 140 ACI 030 00
- Ethernet Communication Module: NOE 771 01
- Profibus DP Master: PTQ PDP MV1

The control panel will provide minimum 20% spare I/O of each type, 10% spare slot capacity and 25% spare power supply capacity including all necessary cables, communication cards, and accessories for a full functional system. The local control panels will include incoming power transient surge suppression and an UPS. The installation will connect the surge suppressor dry contacts and UPS unit to a PLC input and configure as an alarm on the control system as soon as a major surge occurs and / or the UPS battery has a low condition.

Connection to the new Profibus network will be through Prosoft Technologies Profibus DP scanner. The scanners will be connected to the Profibus DP/PA couplers.

Profibus PA network architecture will consist of Profibus PA segments connected to the Profibus DP/ PA couplers and Profibus PA segment protectors. Each individual Profibus PA instrument will be connected to a dedicated segment protector port (spurs). The segment protectors will be installed in the dedicated junction boxes and will have the following features:

- Short circuit protected spurs
- Non-incendive spurs
- Built-in selectable segment terminator
- LED indication lights

The PLC software applications installed will control and monitor all the aspects of the process. It will store, display and control operating parameters and generate alarms and reports to local operating interface (OI) when parameters and equipment are out of normal functional range. Alarms will be treated locally by generating the alarm condition and stopping/halting the equipment that generated the condition or the "cause" associated with the equipment. All alarms will be enunciated through the plant control system computers and logged in the plant electronic log residing on the PCS server's hard drives. Each alarm will have three states:

- Active and Not-acknowledged
- Active and Acknowledged
- Non-active and Not-acknowledged

An alarm will be acknowledged from the PCS Wonderware in Touch application.

The PLC system will be provided with a "watch-dog" module to monitor power failure and utility black-outs, to revert to functioning condition once the power is re-established though the plant (or emergency generator started). The supervision module hardware/software will discriminate between normal operation (on utility power) and on stand-by power.

9.8 Operator Interface

The PCS software will assist the plant operators in control, monitoring and supervision of plant processes, allowing the operator to control process equipment in auto mode from the control system. The PCS software will allow the monitoring, storing, displaying and archiving of operating data and alarms, and to generate reports on existing data and to perform various process control functions from a remote location.

9.9 Field Instruments

Field bus technology offers many advantages (devices provide considerably more information than just the 'traditional' measured variables) and provides an economical system that will support future expansions. However, the technology where instruments are hardwired to the associated PLCs will also be considered. The final decision will be made once the number of instruments is determined during detailed design.

Examples of technology, complete with connection method to the control system, that would be utilized are as follows:

- Magnetic flow meters for piped liquid flow applications (Siemens) – Profibus DP
- Hardwired floats for low level and overflow protection (Flygt) - hardwired
- Thermal mass flowmeters for air flow (FCI, E+H) – 4-20mA hardwired
- DO sensors for dissolved oxygen measurement (E+H, Hach) – Profibus DP
- Motorized Actuators (Rotork) – Profibus DP
- Pressure Transmitters (Siemens) – 4-20mA hardwired
- On/Off Valves – hardwired

10.0 COST ESTIMATE

A capital cost estimate has been prepared based on basic unit costs for commodities, budgetary pricing received for major pieces of equipment, and recent construction costs for projects of a similar size and scope.

The cost estimate for the Bowser Village Wastewater Servicing is summarized in **Table 10.1**.

Table 10.1 – Cost Estimate - Summary

Item	Cost Estimate
Wastewater Treatment Plant	$4,091,000
Collection System	$4,052,000
Outfall (Option A or B)	$2,341,000 to $2,990,000
Permitting, Archaeological, Engineering	$788,000
TOTAL	**$$11,272,000 to $11,921,000**

A more detailed breakdown of the capital cost estimates is provided on the following pages.

Cost Estimate - Details

CAPITAL COST ESTIMATE							
Division				**Quantity**	**Unit**	**Unit Price**	**Phase I Cost**
1	**GENERAL REQUIREMENTS**						
	.1		Mobilization/Demobilization	1	LS	$80,000	$80,000
	.2		Start-up and Commissioning	1	LS	$30,000	$30,000
	.3		O&M Manuals and Record Drawings	1	LS	$20,000	$20,000
	Sub-total:						**$130,000**
2	**CIVIL SITEWORKS**						
	.1		Site Preparation	1200	m2	$20	$24,000
	.2		Excavation	1200	m3	$20	$24,000
	.3		Yard Piping	125	m	$200	$25,000
	.4		Yard Piping Fittings & Installation		LS		$21,250
	.5		Paving	950	m2	$50	$47,500
	Sub-total:						**$141,750**
3	**STRUCTURAL**						
	.1		Building				
		.1	Slab and footings	120	m3	$1,300	$156,000
	.2		Tankage concrete requirement				
		.1	SBR(with baffle wall)	119	m3	$1,300	$154,700
		.2	Splitter Box	20	m3	$1,300	$26,000
		.3	Effluent Equalization	54	m3	$1,300	$70,200
		.4	UV and Screening Channels	3	m3	$1,300	$3,900
		.5	Sludge Storage	37	m3	$1,300	$48,100
	Sub-total:						**$458,900**
4	**Building Envelope**						
	.1		Masonry	238	m2	$2,000	$476,000
	.2		Misc Metals (handrails, hatches and grating)				$55,000
	.3		Roofing				$67,000
	.4		Doors and Windows				$60,000
	.5		Finishing				$45,000
	.6		Millwork				$23,000
	Sub-total:						**$726,000**
5	**PROCESS MECHANICAL/SPECIALTY EQUIPMENT**						
	.1		SBR Decanters and Controls, 2 Blowers, fine bubble aeration and WAS pumps				$350,000
	.2		Fine Screens				$143,000
	.3		Sludge Tank Aeration Grid				$30,000
	.4		Sludge Tank Blower				$20,000
	.5		Effluent EQ Pumps				$24,000
	.6		UV				$43,400
	.7		Gates and Telescoping Valves	9	each	$8,000	$72,000
	.9		Piping / Valving				$91,560
	.10		Installation				$341,200
	Sub-total:						**$1,115,160**
6	**BUILDING MECHANICAL**						
	.1		Odour Control				$74,250
	.2		HVAC Equipment				$243,000
	.3		Ductwork				$330,000
	.4		Plumbing & Fixtures				$75,000
	Sub-total:						**$722,250**
7	**ELECTRICAL / INSTRUMENTATION**						
	.1		Electrical				$290,000
	.2		Instrumentation				$135,000
	Sub-total:						**$425,000**
SUB-TOTAL							**$3,719,060**
8.0	**CONTINGENCY (10%)**						**$371,906**
TOTAL PRICE (Excluding GST)							**$4,090,966**
Notes:	1		General requirement costs include mobilization, start-up and commissioning, O&M manuals and demobilization				
	2		Civil costs include site preparation and yard piping				
	3		Structural costs include all process tanks and buildings. The building costs include modest architectural treatment.				
	4		Process costs inlcude all unit process equipment, installation and interconnecting piping and valves.				
	5		Building mechanical includes odour control, heating and ventilation, and domestic plumbing.				
	6		Electrical and instrumentaiton includes the primary feed, lighting, control hardware and programming.				

	Linear works Opinion of Probable Costs				
Owner:	Regional District of Nanaimo				
Project:	Bowser Village Wastewater Servicing				
Schedule A - General Conditions					
Item	**Description**	**Units**	**Quantity**	**$/Unit**	**Cost**
A.1	Mobilization/Demobilization	Lump Sum	1	$180,000.00	$180,000.00
A.2	Bonding/Insurance	Lump Sum	1	$30,000.00	$30,000.00
A.3	100 mm watermain from existing watermain to treatment building	m	300	$120.00	$36,000.00
A.4	Clearing and grubbing	m²	7000	$5.00	$35,000.00
A.5	Strip and remove organic soils	m³	2500	$3.00	$7,500.00
A.6	Access Road base material	m³	550	$50.00	$27,500.00
A.7	Access Road Sub-base material	m³	2000	$45.00	$90,000.00
A.8	Rock Removal (provisional)	m³	100	$300.00	$30,000.00
A.9	Asphalt Paving	m²	2000	$80.00	$160,000.00
A.10	General Conditions - site trailer, communications, Project Manager	Lump Sum	1	$55,000.00	$55,000.00
Total Schedule A					$651,000.00
Schedule B - Low Pressure System 50 mm forcemain and service connections					
Item	**Description**	**Units**	**Quantity**	**$/Unit**	**Cost**
	50 mm Pressure Forcemain, Valves and Fittings				
B.1	50mm DR11 HDPE Force Main	m	920	$100.00	$92,000.00
B.2	50mm Flushout assembly (installed as per drawing BV-C-203)	Each	4	$2,400.00	$9,600.00
B.3	50mm check valves assembly (installed as per drawing BV-C-203)	Each	1	$5,000.00	$5,000.00
	Low Pressure Service connections				
B.4	Service connections from PVC gravity main to existing houses complete with 50 mm saddle, 50mm HDPE pipe (length as required), 50 mm gate valve, 50 mm check valve and valve box	Each	24	$2,500.00	$60,000.00
B.5	Service connections from LPS 50mm forcemain to existing houses complete with 50X50X50 mm HDPE butt fused T, 50mm HDPE pipe (length as required), 50 mm gate valve, 50 mm check valve and valve box	Each	12	$2,500.00	$30,000.00
B.6	Pumps - Contractor to supply individual pumps to property owners	Each	36	$5,000.00	$180,000.00
Total Schedule B					$376,600.00
Schedule C - Gravity main/service connections and trunk Forcemain Piping 75 & 100 mm					
Item	**Description**	**Units**	**Quantity**	**$/Unit**	**Cost**
C.1	Manholes	Each	39	$5,000.00	$195,000.00
C.2	Safety Manhole (5+m depth)	Each	1	$8,000.00	$8,000.00
	75 mm Pressure Forcemain, Valves and Fittings				
C.3	75mm DR11 HDPE Force Main	m	300	$200.00	$60,000.00
C.4	75mm check valves assembly (installed as per drawing BV-C-203)	Each	2	$5,000.00	$10,000.00
C.5	100mm HDPE Force Main	m	740	$225.00	$166,500.00
	Gravity Main, Valves and Fittings				
C.6	200mm PVC	m	895	$275.00	$246,125.00
	Common Trenchline Piping				
C.7	200mm Gravity PVC and 75mm HDPE Forcemain	m	515	$350.00	$180,250.00
C.8	200mm PVC and 100mm HDPE Forcemain	m	805	$400.00	$322,000.00
	Railroad Crossing				
C.9	Highway 19A crossing (as per detail 4 on Drawing BV-C-202). To include robars and joint restraints for PVC pipe, gate valves and pipe carriers.	m	10	$10,000.00	$100,000.00
C.10	Henry Morgan Drive Crossing (as per detail 5 on Drawing BV-C-202). To include robars and joint restraints for PVC pipe, gate valves and pipe carriers.	m	17	$7,000.00	$119,000.00
	Gravity Service connections				
C.11	Service connections from PVC gravity main to existing houses complete with 100 mm x 200 wye, pipe stubbed at property line.	Each	33	$1,500.00	$49,500.00
Total Schedule C					$1,456,375.00

Item	Description	Units	Quantity	$/Unit	Cost
Schedule D - Pump Station Installation					
	Pump Station # 1 - Supply and Installation				
D.1	Site Works - Div 2	Each	1	$60,000.00	$60,000.00
D.2	Concrete - Div 3				
	A) Valve Chamber	Each	1	$30,000.00	$30,000.00
	B) All Other Concrete Works (service pads, anti-buoyancy slab, etc.)	Each	1	$20,000.00	$20,000.00
D.3	Metal - Div 5	Each	1	$25,000.00	$25,000.00
D.4	Process Mechanical - Div 11				
	A) Wastewater Pumps	Each	1	$60,000.00	$60,000.00
	B) Process Piping & Valves	Each	1	$30,000.00	$30,000.00
	C) FRP Wet Well Tank	Each	1	$55,000.00	$55,000.00
	D) All Other Works	Each	1	$20,000.00	$20,000.00
D.5	Electrical - Div 16	Each	1	$130,000.00	$130,000.00
D.6	Instrumentation - Div 17	Each	1	$70,000.00	$70,000.00
	Pump Station # 2 - Supply and Installation				
D.7	Site Works - Div 2	Each	1	$40,000.00	$40,000.00
D.8	Concrete - Div 3				
	A) Valve Chamber	Each	1	$20,000.00	$20,000.00
	B) All Other Concrete Works (service pads, anti-buoyancy slab, etc.)	Each	1	$15,000.00	$15,000.00
D.9	Metal - Div 5	Each	1	$15,000.00	$15,000.00
D.10	Process Mechanical - Div 11				
	A) Wastewater Pumps	Each	1	$30,000.00	$30,000.00
	B) Process Piping & Valves	Each	1	$20,000.00	$20,000.00
	C) FRP Wet Well Tank	Each	1	$30,000.00	$30,000.00
	D) All Other Works	Each	1	$10,000.00	$10,000.00
D.11	Electrical - Div 16	Each	1	$110,000.00	$110,000.00
D.12	Instrumentation - Div 17	Each	1	$60,000.00	$60,000.00
	Pump Station # 3 - Supply and Installation				
D.13	Site Works - Div 2	Each	1	$40,000.00	$40,000.00
D.14	Concrete - Div 3				
	A) Valve Chamber	Each	1	$20,000.00	$20,000.00
	B) All Other Concrete Works (service pads, anti-buoyancy slab, etc.)	Each	1	$15,000.00	$15,000.00
D.15	Metal - Div 5	Each	1	$15,000.00	$15,000.00
D.16	Process Mechanical - Div 11				
	A) Wastewater Pumps	Each	1	$30,000.00	$30,000.00
	B) Process Piping & Valves	Each	1	$20,000.00	$20,000.00
	C) FRP Wet Well Tank	Each	1	$30,000.00	$30,000.00
	D) All Other Works	Each	1	$10,000.00	$10,000.00
D.17	Electrical - Div 16	Each	1	$110,000.00	$110,000.00
D.18	Instrumentation - Div 17	Each	1	$60,000.00	$60,000.00
Total Schedule D					$1,200,000.00
				Contract Value	$3,683,975.00
				Contingency (10%)	$368,397.50
				Contract Total	$4,052,372.50

	Linear works Opinion of Probable Costs - Outfall Option A				
Owner:	Regional District of Nanaimo				
Project:	Bowser Village Wastewater Servicing				
Schedule E - Outfall Option A					
Item	**Description**	**Units**	**Quantity**	**$/Unit**	**Cost**
E.1	Manholes	Each	24	$5,000.00	$120,000.00
	Gravity Main, Valves and Fittings				
E.2	200mm PVC	m	1540	$275.00	$423,500.00
E.3	200mm HDPE	m	1660	$300.00	$498,000.00
Total Schedule E					$1,041,500.00
				Contract Value	$1,041,500.00
				Contingency (30%)	$312,450.00
				Contract Total	$1,353,950.00

	Linear works Opinion of Probable Costs - Outfall Option B				
Owner:	Regional District of Nanaimo				
Project:	Bowser Village Wastewater Servicing				
Schedule E - Outfall Option B					
Item	**Description**	**Units**	**Quantity**	**$/Unit**	**Cost**
E.1	Manholes	Each	29	$5,000.00	$145,000.00
	Gravity Main, Valves and Fittings				
E.2	200mm PVC	m	1940	$275.00	$533,500.00
E.3	200mm HDPE	m	1660	$300.00	$498,000.00
Total Schedule E					$1,176,500.00
				Contract Value	$1,176,500.00
				Contingency (30%)	$352,950.00
				Contract Total	$1,529,450.00

Appendix A

Bowser Sanitary Sewer Design Concept,
Revision 4, March 31, 2017

Bowser Sanitary Sewer Design Concept

Prepared for:
The Regional District of Nanaimo

Prepared by:
Stantec Consulting Ltd.
400 – 655 Tyee Rd.
Victoria, BC.

March 31, 2017

Rev. 4

Sign-off Sheet

This document entitled Bowser Sanitary Sewer Design Concept was prepared by Stantec Consulting Ltd. (“Stantec”) for the account of The Regional District of Nanaimo (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ____
(Signature)

Alan Ghanam, P. Eng. Managing Principal

Reviewed by ____
(Signature)

Tony Brcic, P. Eng. Senior Project Manager

Table of Contents

LIST OF TABLES

LIST OF FIGURES

1.0 BACKGROUND

1.1 INTRODUCTION

The Regional District of Nanaimo (RDN) recently received Federal Gas Tax Funding to pursue "Rural Village Centre Sewer Servicing Projects". As part of this program the Bowser Village Centre has received funding for the preparation of a detailed design and cost estimate for the provision of a wastewater system that includes service connections, collection, treatment and disposal for the Bowser Village Centre.

Bowser Village is located in Electoral Area 'H' in the RDN and has been identified as having great potential to becoming a "complete compact community". The Official Community Plan (OCP) and Liquid Waste Management Plan align with the RDN's goal to provide community wastewater services to the Bowser Village Centre. Not including the Future Use Area the current population of Bowser Village is approximately 117 people. This number was determined using the RDN's recommended density for current population estimates.

The *RFP – Bowser Village Centre Wastewater* Service states that "the population of the Bowser Village Centre is estimated at 889 (540 units) in year 2030." This number of 889 was obtained from the *Feasibility Study for Area-H Bowser Community Sewer Servicing Study, (Chatwin, March 2011)*. Upon review of the Chatwin Feasibility Study Stantec has determined that the expected population referenced in the study only accounts for the Bowser Community Stakeholder (BCS) group lands which includes just over one third of the total area within the Bowser Village Centre. For a village centre of Bowser's size and current density Stantec has included our reasoning and suggested projection values for use in the conceptual design. As described in Section 3.2.3 Stantec's projection for a 20 year build out to 2036 for the entire Bowser Village is 310. This number was approved by the RDN and obtained by projecting a 5% population growth per year, which is similar to communities experiencing steady growth.

2.0 DESIGN CRITERIA

Stantec has performed the calculations for the Sewer Demand based on the RDN Bylaw No. 500 Schedule 4D in conjunction with information and recommendations in the OCP. Design population density projections from the Bowser OCP were not utilized in this report to calculate build out populations since the OCP does not state a time frame to reach ultimate build-out.

2.1 BOWSER VILLAGE OCP

The 2010 OCP was used to calculate the predicted current/future populations. At the time the OCP was published the residential population density within the original Bowser Village Centre boundary was estimated by using 1.6 units per hectare (UPHA) with 2.1 people per unit. We have since received comment from the RDN to utilize a 1.1 UPHA density with the same estimated 2.1 people per unit for the current 2016 population calculation.

For future development the OCP incorporates a "realistic" estimate of developed units by using only 50% of the target residential density for Com-mixed use, and Civic use zoned lands as they are likely to include other uses for the property. There is also a suggested calculated density reduction of 20% for all parcels due to setbacks, parking, roads etc. Even when calculating to the "realistic" estimates in the OCP Stantec finds that the predicted 2040 build out population number is quite aggressive. The growth from the 2016 estimated population to the 2040 target density ultimate buildout is from 117 people to over 2400 people (a growth of over 2000%).

Stantec has, for this report, only used the recommendations received from the RDN's review of the first revision of the pre-design report to estimate the 2016 population, which is to assume a 1.1 UPHA density for Bowser village with a 2.1cap/unit population. The 20 year build out population has been calculated in section 3.0 which, as you will see, avoids using the density targets as suggested in Section 4.1.5 of the OCP (20 units per hectare by 2025 and 30 units by 2040) as the numbers suggest an unlikely growth rate.

Refer to Table 3-1 for the current and expected build out populations for Bowser Village.

2.2 RDN BYLAW NO. 500 – SCHEDULE 4D: COMMUNITY SEWER SYSTEM STANDARDS

To calculate the design sewage flows the Regional District of Nanaimo have their own design specifications in Bylaw No. 500 – Schedule 4D which was referenced. Specifications in particular to note for the conceptual design are found under Schedule 4D's Section 2.0 - Design:

2.2.1 Sewage Quantity

Schedule 4D Section 2.1 – Sewage Quantity details how the RDN calculate peak sewage flows, which is as follows:

1. In general, provision shall not be made in sanitary sewer system designs for the deliberate addition of stormwater.

2. Design sewage rates of flow shall be computed by adding peak sewage flow to peak stormwater infiltration.

3. Peak sewage flow shall be established by multiplying the peak unit AWWF (Average Wet Weather Flow) shown in Section 2.1 (of Schedule 4D) by the design contributory population except in industrial and commercial areas where other methods, approved by the District, may be used. (refer to Figure 2.1 Bylaw 500 Table 1 Design for Peak Sewage Flows)

4. Peak stormwater infiltration shall be calculated on the basis of 10 m^3/ha of design tributary area per day.

5. Design contributory populations shall be computed in accordance with the Regional District of Nanaimo population predictions or with the ultimate planned development in the tributary area, whichever is the larger.

6. In the absence of detailed population information, the following minimum design population densities shall be used:

   a. One dwelling unit/parcel 30 persons/ha

   b. Two dwelling units/parcel 50 persons/ha

   c. Multiple dwelling unit development 125 persons/ha

   d. Industrial/commercial zoning 50 persons/ha

The following figure is used for establishing peak dry weather flows based on the contributing population to the collection area.

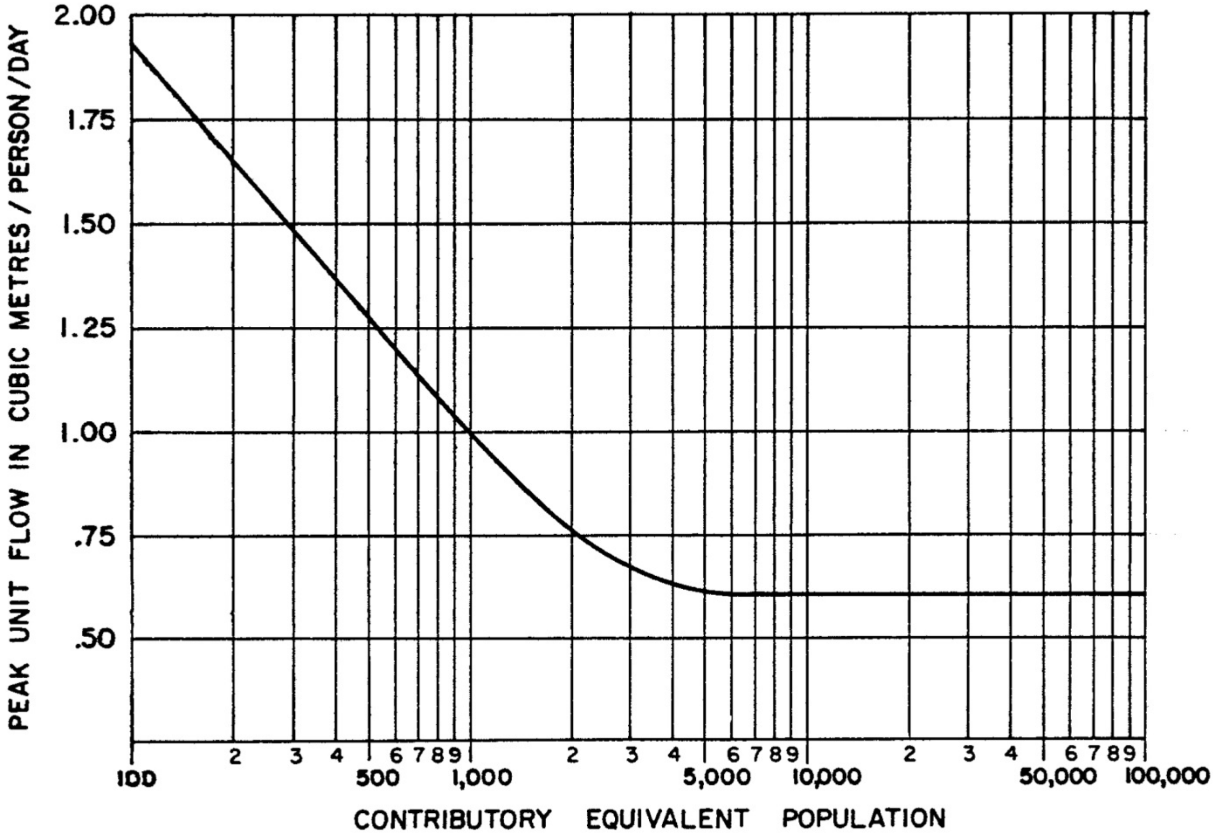


Figure 2.1 Bylaw 500 Table 1 Design for Peak Sewage Flows

2.2.2 Hydraulics

Section 2.3 of Schedule 4D covers the hydraulic requirements involved in sewer system design. These guidelines have been used during the preliminary and detailed design phases.

1. All facilities shall be designed to convey peak sewage flows plus peak stormwater infiltration (design flow).

2. Sewers shall be designed to carry design flow at a minimum velocity of 0.67 m/s. When carrying the design flow the maximum depth of flow shall not exceed the following:

   a. 250 mm and smaller - one-half pipe diameter

   b. 300 mm to 400 mm - three-quarter pipe diameter

   c. 500 mm and over - full pipe diameter

3. Service connections shall be designed for a minimum velocity of 0.90 m/s when flowing full.

4. The minimum velocity in a forcemain shall be 0.76 m/s.

5. Manning's Roughness Coefficient of 0.013 shall be used for design of sewers and service connections. Manning's Roughness Coefficient of 0.015 shall be used for forcemains and outfalls.

6. Manholes shall be designed to incorporate a minimum elevation differential of 30 mm in addition to the normal grade of the lateral sewer, wherever a horizontal deflection exceeding 45° occurs.

7. Pumping stations and treatment and disposal works shall be designed to process all peak sewage flows plus stormwater infiltration. Bypassing of works to disposal shall not be allowed except under emergency conditions.

2.3 DESIGN CONSIDERATIONS

The following are guidelines that Stantec anticipates the need to deviate from for the Bowser Village sewer system design

1. The RDN stipulated minimum forcemain size of 100mm.

2. The Population target density projections suggested in the Bowser OCP and RDN guidelines.

3. Stantec typically uses the Hazen-Williams formula and not the Manning's equation for calculating sewage forcemains.

Further explanation for the deviations can be found in Sections 3.1 and 4.4 which cover the reasoning behind the proposed changes.

3.0 LAND USE AND POPULATION PROJECTIONS

3.1 CONSIDERATIONS AND CLARIFICATIONS

Stantec proposed to deviate from the expected population growth included in the Bowser OCP as well as the 2011 feasibility report due to the following:

- The feasibility report states that the BCS group lands would start developing and by 2015, increase the population to approximately 263 people. Through discussions with the RDN, Stantec understands that no major developments have taken place to date, or are expected in the near future; therefore, the population increase suggested in the feasibility study is not used.

- The OCP uses 20 UPHA (units per hectare) as a target density for 2025, but again there has been no indication from RDN of any major development that has taken place or is scheduled to. The growth to 20 UPHA from the RDN estimated 1.1 UPHA current (2016) condition is an extremely large increase not typically seen in smaller communities such as Bowser without a major industry expansion coinciding.

- To design to the recommended growth in the OCP and Feasibility study would increase the design/construction costs substantially and when the designed flows are not encountered then there will potentially be many issues that could arise. Some of the more prevalent issues can be found in Section 4.4 Sewage System Considerations and Clarifications.

- To determine the current 2016 village population Stantec utilized the suggested density of 1.1 UPHA and 2.1 people/unit from the RDN's review of Stantec's first revision of the predesign concept report, which deviates from the OCP suggested 2010 population density of 1.6 UPHA and 2.1 people/unit.

The sewage system design considerations can be found in Section 4.4

3.2 PROJECTIONS

3.2.1 Land Use

The desired future land use for the Bowser Village Centre is shown on the following Figure 3.1. Bowser Village has a variety of different zonings but is predominantly zoned Residential (high and medium density) north of highway 19A with a large Commercial Mixed Use zoned south of the highway in the Village Centre area.

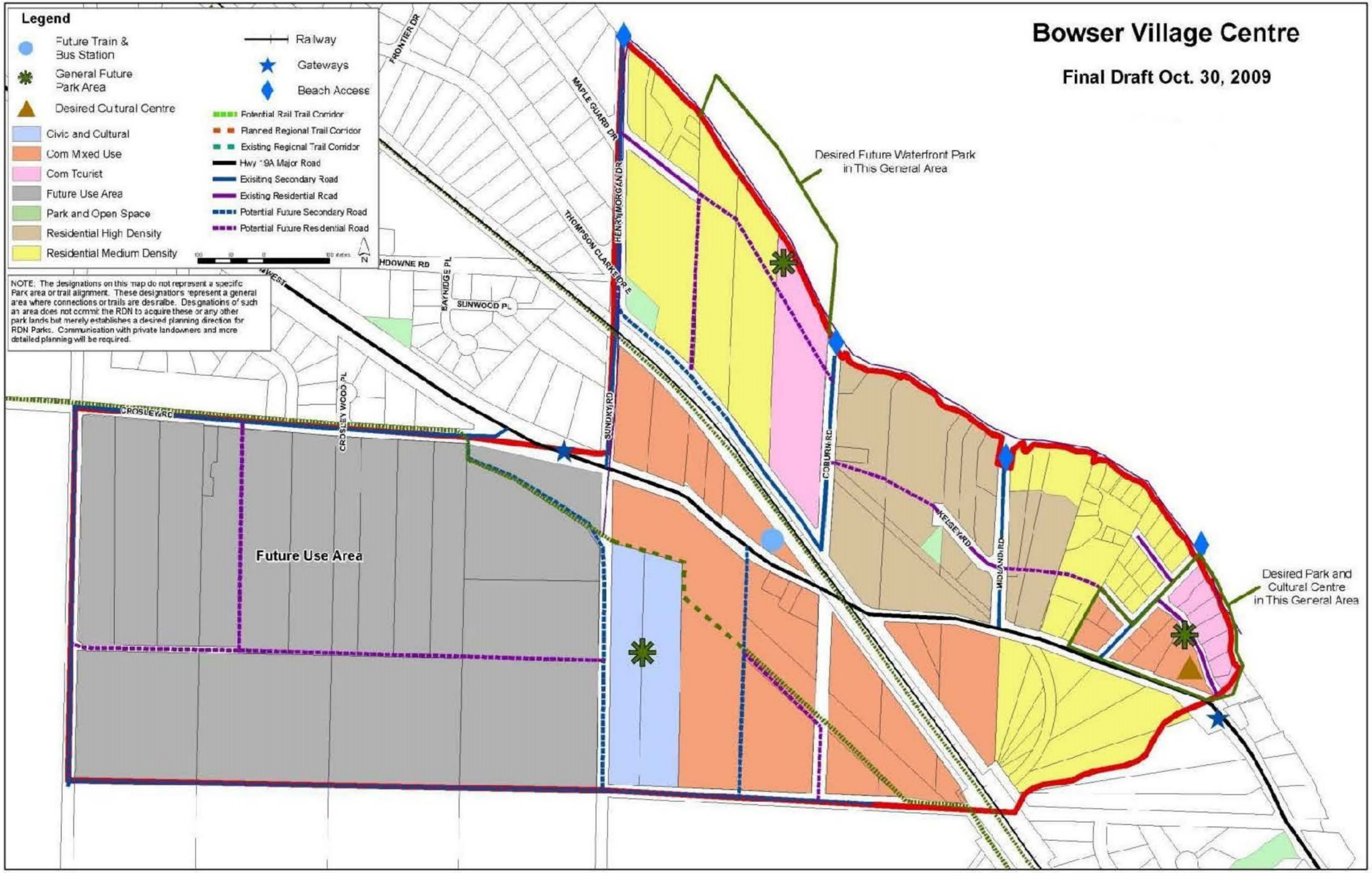


Figure 3.1: Zoning Map for Land Use within Bowser Village Centre (Taken From Bowser Village Plan)

3.2.2 OCP Land Use Densities

The OCP states the following land use densities for a 2040 ultimate build out:

Land Use Designation	2040 Target Density in units per hectare (UPHA)
Commercial – Mixed Use	35 UPHA
Residential – High Density	45 UPHA
Residential – Med. Density	35 UPHA
Civic and Cultural	35 UPHA
Commercial – Tourist	10 UPHA

Stantec have reviewed the study area, utilizing the density projections included in the OCP and Feasibility Study. These calculations are shown in Section 3.2.3 of this report with explanation of any deviation for build out scenarios in Section 3.1.

3.2.3 Population Projections

It is anticipated that the population of the study area will change if some of the BCS group's proposed developments come online and the area is better serviced by both water and sewer. It is likely that the existing residential areas with small parcels will remain the same but larger parcels will be subdivided to permit various uses.

Primary utilities, such as gravity sewer lines, are typically designed for the 50 year horizon, while sewage treatment facilities, sewage pump stations and water supplies are sized on the 20 year population projection. It is therefore necessary to make assumptions on the rate and extent of future development so infrastructure can be planned accordingly.

The feasibility study (Chatwin, March 2011) states that the intended development of the BCS group is to reach a build out by 2030 which could see a population of 889 people within these properties.

Through ongoing discussions with the RDN there is no indication as to any development within the Bowser Village Centre area; therefore, a uniform growth based on a conventional 5% growth per year was used for the next 20 years to calculate a more realistic build out. Stantec proposes to deviate from the suggested OCP Density Targets of 20 UPHA and 30 UPHA by 2025 and 2040 respectively as these numbers indicate an extreme growth rate that Stantec believes to be unreasonable for design purposes. The reasoning for this assumption is included above in Section

3.1. The attached Table 3-1 includes Stantec's anticipated 20 and 50 year growth for Bowser Village.

Table 3-1 Population Buildout projected over 20 and 50 year periods.

Bowser Village Development areas	Size (ha)	Size (ha) with 20% reduction as per OCP	2016 Current Population (capita)*	Stantec's 2036 anticipated population at growth of 5 %/yr. (capita)	Stantec's 2066 anticipated population at growth of 5 %/yr. (capita)
BCS group area	21.74	17.39	50	133	576
Remaining Village Lands	28.87	23.09	67	177	765
Total	50.61	40.48	117	**310**	1341

* 2016 population calculation does not take into account 20% reduction in area for setback, roadways, etc. Value calculated using recommended density values from the RDN review of Stantec's first revision of the draft pre-design report.

4.0 COLLECTION SYSTEM DESIGN

4.1 SEWAGE COLLECTION AND DISPOSAL

4.1.1 Existing Systems

The Community of Bowser Village is currently serviced by individual aging septic tanks and each individual residence/building within the Bowser Village currently discharges their sewage to ground. In some cases the systems can be expected to be at or near the end of their life cycles.

By bringing the village online to a sewage treatment system the Village of Bowser is providing quality wastewater treatment for its residents with consideration for future developments.

4.1.1.1 Current Conditions

By using the OCP guidelines for calculating the current population and incorporating that number into RDN Bylaw 500 – Schedule 4D design guidelines we are able to calculate the current expected flows.

The current expected flow for the entire Bowser Village (excluding the "Future Use" area) is approximately 7.33 L/s as shown in the table below.

Table 4-1: Current 2016 Bowser Village Sewage Flow Calculations

Total Area (hectares)	50.6
2016 Unit Density (units/hectare) – from RDN	1.1
Population Density – from OCP	2.1
Total 2016 Population (capita)	117
Stormwater Infiltration Rate (m^3/ha/d) – RDN Bylaw 500	10
Stormwater Infiltration (m^3/d) – *does not include LPS catchment areas*	411
Peak Sewage Flow (from Figure 2.1) m^3/cap/d – RDN Bylaw 500	1.90
Peak Dry Weather Flow (m^3/d)	222.3
Peak Wet Weather Flow (PWWF) = PDWF + I&I (m^3/d)	633.3
Total PWWF for Bowser Village (L/s)	**7.33***

* Total PWWF includes the Low Pressure System (LPS) area as shown in yellow in Figure 4.1.

4.1.2 Proposed Developments

There is a large potential for the existing lots within the proposed service area to be subdivided as per the OCP, which could add a significant number of connections into the proposed sanitary system and this study analyses the options for efficiently collecting and treating the current effluent and eliminating or minimizing potential impacts on the system due to future community growth.

The 2011 feasibility study performed by Chatwin Engineering mentions that there are multiple stakeholders with plans for development in the near future. The Bowser Community Stakeholder (BCS) group is comprised of:

- Canadian Legion
- Seniors housing
- Coral Ice
- Magnolia Enterprises
- AG Project Management
- Tomm's Food Market
- Green Thumb Nursery

The lands owned by the BCS group comprise approximately 21.7 hectares of area with owners expressed intent to develop.

Bowser Village Development areas	Size (ha)
BCS group area	21.74
Remaining Village Lands	28.87

Development within the lands owned by the BCS group is dependent on sewer servicing, as well as, zoning changes, water servicing, roadways, etc. Through recommendation of the RDN a growth rate of 5% per year has been used to project the population increase in these areas as well.

4.2 COLLECTION SYSTEM DESIGN

The design stage for sewage collection and delivery to the Waste Water Treatment Plant (WWTP), which is anticipated to be located in the southwest of Bowser Village due to suitable ground conditions and zoning allowances, includes a gravity collection system and 3 pump stations to pump the sewage to the WWTP from various low points in the gravity collection systems.

This option will utilize a 200mm minimum diameter gravity system capable of handling the anticipated ultimate build out conditions, which will follow the contours of Bowser Village topography and collect and deliver flows to 3 separate pumping stations. Following the RDN guidelines one section of gravity main is proposed to be 150mm diameter and this will be along Park Avenue, as the sewer line cannot be extended further and the collection area is relatively small.

There are 3 pump stations within the design, located as shown on Figure 4.1, which displays the catchment areas for each of the stations.

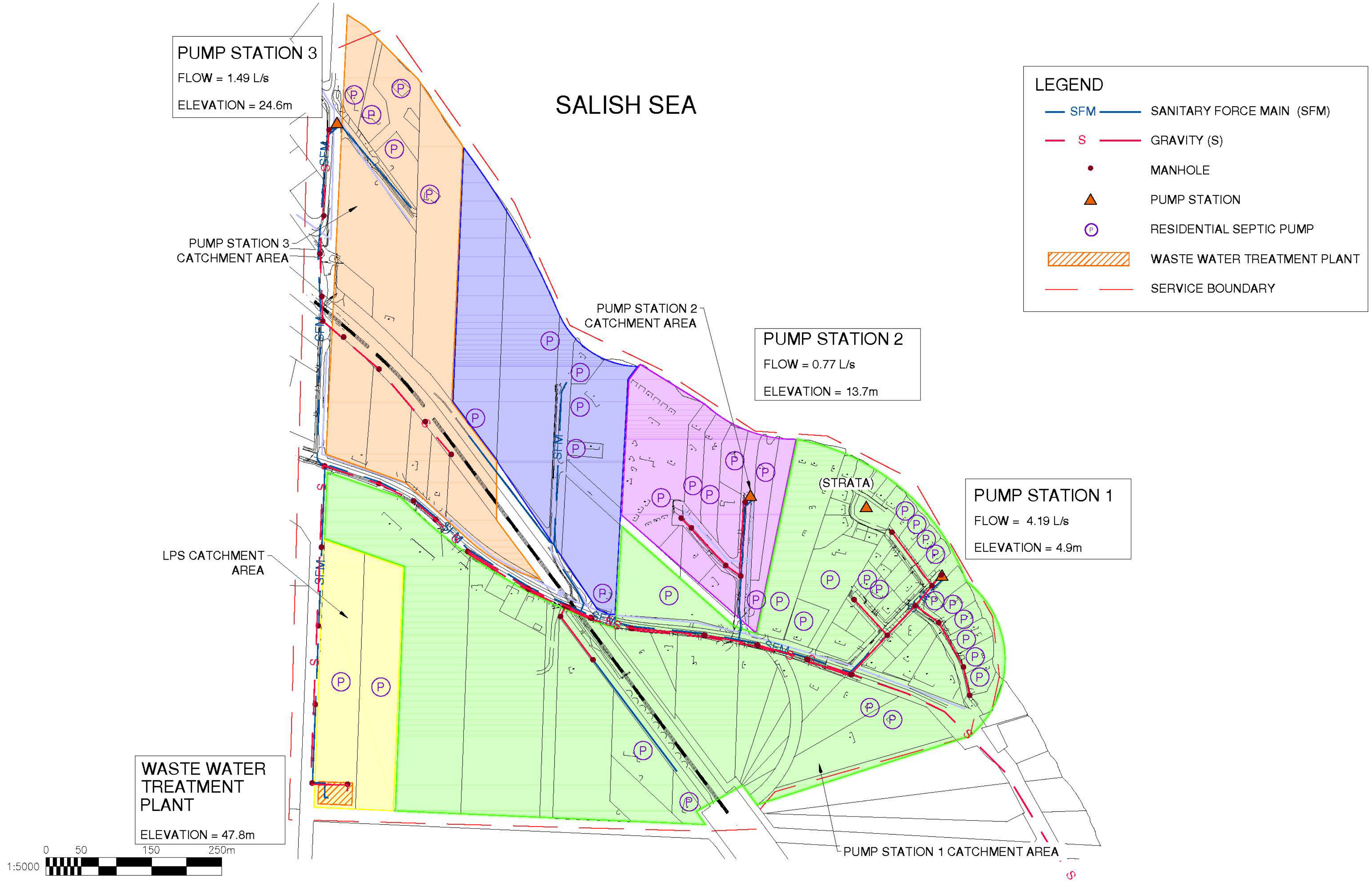


Figure 4.1: Pump Station Location and Catchment Area

Pump Station #1

Pump Station #1 will be located at the north end of Bowser Road. This pump station

PS #1 has the largest collection area as the gravity line will feed from Magnolia Court to the bottom of Bowser Road. The collection area for this pump station is approximately 25ha (green shading).
The elevation of PS #1 will be close to sea level and it will be required to pump the flows to a final elevation of approximately 50m at the WWTP.

This station is designed to include:

- A 1.5m diameter Fibreglass Reinforced Polymer (FRP) wet well with stainless steel piping
  - Sized for the 20 year build out flows.
- A conventional alternating duplex 23 hp submersible pump system
- A kiosk to provide the pump controls and connect into the WWTP SCADA system for monitoring and alarms
- A backup diesel genset to power the station in the event of a power outage.

A live storage volume of 1590 litres, or corresponding to 0.9m live depth, (difference between the start and stop elevations) will be provided. Critical flow pump cycling was assessed using this volume to ensure the pump(s) would not cycle more than 6 times during a one hour period.

Pump Station #2

Pump Station #2 will be installed on Midland Road. The catchment area (purple shading) contributing to this PS is zoned as high density and medium density residential and is approximately 4.6ha in size. This pump station will deliver sewage via 75mm forcemain into the 100mm forcemain originating from PS #1, at the intersection of Midland and Highway 19A, which will direct flows to the WWTP.

The station is designed to include:

- A 1.2m diameter Fibreglass Reinforced Polymer (FRP) wet well with stainless steel piping
  - Sized for the 20 year build out flows.
- A conventional alternating duplex 11 hp submersible pump system

- A kiosk to provide the pump controls and connect into the WWTP SCADA system for monitoring and alarms
- A backup diesel genset to power the station in the event of a power outage.

A live storage volume of 571 litres, or corresponding to 0.5m live depth, (difference between the start and stop elevations) will be provided. Critical flow pump cycling was assessed using this volume to ensure the pump(s) would not cycle more than 6 times during a one hour period.

Low Pressure System along Coburn Road

Individual pump packages will be located along the properties abutting Coburn road and will collect sewage from an approximate 7.6 ha of properties (blue shading) and will pump through a small diameter forcemain into the forcemain from PS #1 at the location where Esary Road meets Hwy 19A and ultimately to the WWTP for treatment.

Pump Station #3

Located on Henry Morgan Drive, Pump Station #3 will collect sewage from 9 hectares of property (orange shading) and pump the flow via a small diameter forcemain which will travel up Henry Morgan Drive, cross underneath the E&N Railroad and be directed up Sundry Road where it will connect into the forcemain from PS #1 at the cross road between Sundry Road and Highway 19A and ultimately be directed to the WWTP for treatment.

The station is designed to include:

- A 1.2m diameter Fibreglass Reinforced Polymer (FRP) wet well with stainless steel piping
    - Sized for the 20 year build out flows.
- A conventional alternating duplex 6 hp submersible pump system
- A kiosk to provide the pump controls and connect into the WWTP SCADA system for monitoring and alarms
- A backup diesel genset to power the station in the event of a power outage.

A live storage volume of 520 litres, or corresponding to 0.46m live depth, (difference between the start and stop elevations) will be provided. Critical flow pump cycling was assessed using this volume to ensure the pump(s) would not cycle more than 6 times during a one hour period.

Low Pressure Systems by WWTP

Low Pressure Systems will be utilized for the two adjoining properties to where the WWTP is anticipated to be located and are shown in yellow shading in Figure 4.1. As there is minimal head to overcome and relatively low flow to transmit it is anticipated that two separate low pressure pump packages will be installed, one for each parcel. The sewage flows will be directed straight into the WWTP.

As Bowser Village develops, future roads and subdivision of properties may change the routing of the sewer system and alter the anticipated flows for each pump station and each of catchment areas shown in Figure 4.1: Pump Station Location and Catchment Area.

4.2.1 Projected Future Demand

The following tables detail the 20 year anticipated build out flows experienced at each Pump Station. The population projections are based off recommendation received from RDN, and finally projected 20 years to 2036 using a growth rate of 5% per year for the area. The sewage flows and infiltration rates were calculated utilizing the RDN Bylaw 500 – Schedule 4D.

For ease of readability and reference we have included the table showing Bowser Village's 20 year population projection.

Table 4-2 Population Buildout projected over a 20 year period.

Bowser Village Development areas	Size (ha)	Size (ha) with 20% reduction as per OCP	2016 Current Population (capita)*	Stantec's 2036 anticipated population at growth of 5 %/yr. (capita)
BCS group area	21.74	17.39	50	133
Remaining Village Lands	28.87	23.09	67	177
Total	50.61	40.48	117	**310**

**population calculation does not take into account 20% reduction in area for setback, roadways, etc. Value calculated using recommended density values from the RDN review of Stantec's first revision of the draft pre-design report.*

Table 4-3: Projected Sewage and Infiltration Rates for Pump Station #1

Pump Station #1 - 2036 anticipated flows	
Total Catchment Area (hectares)	25.15
2016 Unit Density (units/hectare) – from RDN	1.1
Population Density – from OCP	2.1
Total 2016 Population (capita)	58
Projected 2036 Population (capita)	154
Stormwater Infiltration Rate (m³/ha/d) – RDN Bylaw 500	10
Stormwater Infiltration (m³/d)	251.5
Peak Sewage Flow (from Figure 2.1) m³/cap/d – RDN Bylaw 500	1.75
Peak Dry Weather Flow (m³/d)	269.5
Peak Wet Weather Flow (PWWF) = PDWF + I&I (m³/d)	521
Total PWWF for PS #1 (L/s)	**6.03**

Table 4-4: Projected Sewage and Infiltration Rates for Pump Station #2

Pump Station #2 - 2036 anticipated flows	
Total Catchment Area (hectares)	4.62
2016 Unit Density (units/hectare) – from RDN	1.1
Population Density – from OCP	2.1
Total 2010 Population (capita)	11
Projected 2036 Population (capita)	28
Stormwater Infiltration Rate (m^3/ha/d) – RDN Bylaw 500	10
Stormwater Infiltration (m^3/d)	46.2
Peak Sewage Flow (from Figure 2.1) m^3/cap/d – RDN Bylaw 500	1.90
Peak Dry Weather Flow (m^3/d)	53.2
Peak Wet Weather Flow (PWWF) = PDWF + I&I (m^3/d)	99.4
Total PWWF for PS #2 (L/s)	**1.16**

Table 4-5: Projected Sewage Rates for the Coburn Road Low Pressure System

Low Pressure System (Coburn Road) - 2036 anticipated flows	
Total Catchment Area (hectares)	7.64
2016 Unit Density (units/hectare) – from RDN	1.1
Population Density – from OCP	2.1
Total 2016 Population (capita)	18
Projected 2036 Population (capita)	47
Stormwater Infiltration Rate (m^3/ha/d) – RDN Bylaw 500	No Infiltration due to pressurized system
Stormwater Infiltration (m^3/d)	0
Peak Sewage Flow (from Figure 2.1) m^3/cap/d – RDN Bylaw 500	1.90
Peak Dry Weather Flow (m^3/d)	89.3
Peak Wet Weather Flow (PWWF) = PDWF + I&I (m^3/d)	89.3
Total PWWF for Coburn LPS (L/s)	**1.03**

*This LPS is shown in blue shading in Figure 4.1: Pump Station Location and Catchment Area

Table 4-6: Projected Sewage and Infiltration Rates for Pump Station #3

Pump Station #3 - 2036 anticipated flows	
Total Catchment Area (hectares)	8.97
2016 Unit Density (units/hectare) – from RDN	1.1
Population Density – from OCP	2.1
Total 2016 Population (capita)	21
Projected 2036 Population (capita)	55
Stormwater Infiltration Rate (m^3/ha/d) – RDN Bylaw 500	10
Stormwater Infiltration (m^3/d)	89.7
Peak Sewage Flow (from Figure 2.1) m^3/cap/d – RDN Bylaw 500	1.90
Peak Dry Weather Flow (m^3/d)	104.5
Peak Wet Weather Flow (PWWF) = PDWF + I&I (m^3/d)	194.2
Total PWWF for PS #3 (L/s)	**2.25**

Table 4-7: Projected Sewage Rates for the Low Pressure System at the WWTP

Low Pressure System at WWTP - 2036 anticipated flows	
Total Catchment Area (hectares)	4.23
2016 Unit Density (units/hectare) – from RDN	1.1
Population Density – from OCP	2.1
Total 2016 Population (capita)	10
Projected 2036 Population (capita)	26
Stormwater Infiltration Rate (m³/ha/d) – RDN Bylaw 500	No Infiltration due to pressurized system
Stormwater Infiltration (m^3/d)	n/a
Peak Sewage Flow (from Figure 2.1) $m^3/cap/d$ – RDN Bylaw 500	1.90
Peak Dry Weather Flow (m^3/d)	49.4
Peak Wet Weather Flow (PWWF) = PDWF + I&I (m^3/d)	49.4
Total PWWF for LPS (L/s)	**0.57**

*this LPS is shown in Yellow on Figure 4.1: Pump Station Location and Catchment Area

Table 4-8: Total Projected Sewage Rates for the Bowser Village

Bowser Village – 2036 Total anticipated flows	
Pump Station #1	6.03
Pump Station #2	1.16
Coburn Road LPS	1.03
Pump Station #3	2.25
WWTP LPS	0.57
Total PWWF for Bowser Village (L/s)	**11.04**

* *Total PWWF includes 0.57 L/s from the Low Pressure System (LPS) area shown in yellow in Figure 4.1 which is anticipated to connect directly into the WWTP. Total PWWF without WWTP LPS = 10.47 L/s.*

4.3 SEWER SYSTEM LAYOUT

4.3.1 Forcemain Layout

The three pump stations have been sized in anticipation of the 20 year build out flows and as such the designed forcemain layout will not require upsizing throughout this operation. As the current and anticipated future flows are within 2 L/s for the pump stations the pumps will not require upsizing. The pump station pumps are sized to maintain the minimum scouring velocity within their associated forcemains. These minimum required scouring flows are very similar to the anticipated 20 year flowrates within the Village, this allows the current and future flows to be pumped out at the same rate simplifying the design.

The forcemain routing from pump station 1 on Bowser Road will be sized to 100mm and travel the entire length up the highway and up to the WWTP, whereas the forcemains from PS 2 & 3 will be sized at 75mm and connect into the trunk forcemain along the highway. These two latter forcemains are undersized from the RDN requirements due to the fact that there is minimal flow anticipated in these two locations. If the design was required to maintain scouring velocity in 100mm lines for these two sections it would require oversizing the pumps which would be at a greater cost to the RDN, as is mentioned in Section 4.4 below. Included below for your reference and understanding is Table 4-9 which shows the associated flows needed in various forcemain sizes to achieve the required scouring velocity.

Table 4-9: Forcemain Required Scouring Velocities and Flow Rates

Forcemain Diameter (mm)	Scouring Velocity (m/s)	Associated Flow Rate (L/s)	Pump Stations	Sewage Generation Flows for Current/20yr (L/s)
50*	0.76	1.49	Low Pressure Systems	
75	0.76	3.36	Pump Station 2 & Pump Station 3	0.77 / 1.16 1.49 / 2.25
100	0.76	5.97	Pump Station 1	4.19 / 6.03

**Grinder pumps required*

4.3.2 Gravity System

The minimum recommended gravity line size from the RDN design guidelines is 200mm which is capable of handling the 50 yr. build out flows* in each section. The combined flows from the total expected 1341 people in 2066 is approximately 19.5L/s and can be conveyed in one 200mm line with a slope of 0.5%. The design layout, as proposed in this report, will not see the total population flows going through any one section of gravity sewer; therefore it can be anticipated that the gravity system sizing is adequate for the 50 year horizon.

**build out flows due to 5% population increase over 50 years.*

4.4 SEWAGE SYSTEM CONSIDERATIONS AND CLARIFICATIONS

As detailed in the above section, the anticipated diameters of certain forcemains sections are less than the suggested 100mm from the RDN Schedule 4D guidelines. The deviation from the design guidelines is due to the small flows and subsequent small velocities seen in the system. If the RDN requirements are to be maintained for the forcemain minimum design velocity being 0.76 m/s minimum while using 100mm minimum piping then the lift station pumps will be inappropriately sized. Some of potential issues of maintaining the RDN and Bowser OCP design guidelines are discussed in Section 3.1.

Additional considerations are listed below:

- By designing the pump stations to the OCP build out, the wet wells would be oversized and detention times before pump engage could increase, thus causing the sewage to become septic and produce unfavorable odours for nearby residents. It is possible to mitigate the detention times by adjusting the float valves though this will cycle the pumps more frequently and may reduce their life expectancy.
    - The pumps themselves would also be oversized to handle the Bowser OCP 20 year target density build out which would also increase costs significantly.
- Forcemains would also be oversized to handle the expected OCP ultimate build out scenario or to meet the RDN minimum sizing requirements, and would potentially not meet the design guidelines to maintain scouring velocities, potentially creating buildup and maintenance issues.

To maintain the minimum RDN recommended scouring velocities the pump stations have been sized to maintain a minimum flow while in operation. As mentioned above Table 4-9 outlines the minimum pump station discharges required for various forcemain sizes.

The current expected sewage flows fall below the minimum required amount to maintain scouring velocities in the recommended RDN forcemain sizing of 100mm. By utilizing 75mm forcemain for pump station 2 and 3 we lower the required flows to obtain the scouring velocity from 6.0 L/s to 3.4 L/s which is still above the 20 year expected build out flows in these areas. This allows the design to incorporate a smaller and more reasonable pumping system.

5.0 OPINION OF PROBABLE COSTS

Included below is Stantec's Opinion of Probable Costs (OPC) to act as an initial ballpark budgetary assessment. As the design becomes refined in the next stages the costs will be updated and submitted to RDN for review/approval. We are able to cater the design to fit different budgetary allowances and are able to discuss any proposed changes with the RDN at the next meeting. The OPC is as follows:

Item	Description	Unit	Quantity	Unit Price	Amount
1	Low Pressure Mains 50 mm	m	750	$175.00	$131,250.00
2	Gravity mains 150 mm	m	160	$250.00	$40,000.00
3	Gravity mains 200 mm	m	2600	$300.00	$780,000.00
4	Forcemains 75 mm	m	900	$175.00	$157,500.00
5	Forcemains 100 mm	m	1550	$200.00	$310,000.00
6	Gravity Services and Service Line	each	33	$2,500.00	$82,500.00
7	Pump Services and Service Line	each	40	$3,500.00	$140,000.00
8	Pump Package	each	40	$5,000.00	$200,000.00
9	Pumping Station 1 - 23hp	each	1	$450,000.00	$450,000.00
10	Pumping Station 2 - 11hp	each	1	$400,000.00	$400,000.00
11	Pumping Station 3 - 6hp	each	1	$350,000.00	$350,000.00
12	Rail Road crossings	each	2	$100,000.00	$200,000.00
				Sub Total	**$3,241,250.00**
				Engineering, administration and contingencies - 40%	$1,296,500.00
				Total	**$4,537,750.00**

General Notes:

1. Value does not include GST
2. 2016 Dollars
3. Pipe costs include all incidental costs such as traffic management, asphalt restoration, environmental protection, etc.
4. No geotechnical costs are included in this estimate.

Limits of Commission:

Whereas any opinions of probable cost prepared by Stantec Consulting Ltd. ("The Engineer") will be based on incomplete or preliminary information, and will also be based on factors over which the Engineer has no control, the Engineer does not guarantee the accuracy of these opinions of probable cost and shall have no liability where the probable costs are exceeded.

6.0 PROJECT CONSIDERATIONS

6.1 ENVIRONMENTAL CONSIDERATIONS

Bowser being located along the coast of the Strait of Georgia is part of a large and diverse environmentally sensitive ecosystem. Before any development takes place consultation with local and federal regulating bodies will occur to develop a succinct Environmental Management Plan and to discuss the need and depth for an Environmental Impact Study. Possible studies would include but not be limited to:

- Fish habitat protection
- Development near nesting wildlife trees (eagle, heron, etc.)
- Development near watercourses (rivers, streams, oceans)

6.2 ARCHAEOLOGICAL CONSIDERATIONS

As part of the design process one of Stantec's Archaeologists performed an initial desk top review of the Bowser Village Centre. The findings of the review were that all along the waterfront for the entirety of the Village Centre the land is considered to have high archaeological potential with one known archaeological site (DiSd-16) at the proposed Pump Station 1 location.

As discussed in Section 6.3, pump station 1 is located within the known archaeological site due to unsuitable soil conditions outside of the existing arch zone. It is seen as a more viable option to obtain the archaeology permit with the extra costs associated as opposed to designing and constructing retaining and supporting structures to protect the pump station in the original proposed location.

An archaeological impact assessment (AIA) under the authority of a *Heritage Conservation Act* (HCA) heritage inspection permit is recommended to identify the extent of conflict between the Project and archaeological site DiSd-16. The AIA will involve surface inspection and subsurface testing of the proposed development area. A combination of shovel and auger tests will be hand excavated within and adjacent to the portion of the Project footprint in conflict with DiSd-16. Monitoring of any geotechnical drilling proposed within DiSd-16 is proposed as part of the AIA. Pedestrian survey of the property and subsurface tests will be mapped an all information will be presented in a final report. Updated site information will be recorded on appropriate government inventory forms. A management plan in the form of a series of recommendations will be provided. All work will be conducted in accordance with provincial archaeological guidelines administered by the Archaeology Branch.

Acquisition of an HCA permit typically takes about six to eight weeks due to a 30-day review period granted to relevant First Nations, and the processing time required by the Archaeology Branch.

6.3 GEOTECHNICAL CONSIDERATIONS

On June 7, 2016 WSP Canada Inc. performed a subsurface geotechnical investigation relating to the proposed pump station locations. The subsurface investigation determined that the soils in the proposed locations of pump stations 2 & 3 would provide adequate support for the pump station structures; whereas, the soils in the proposed location of pump station 1 provide geotechnical concern for the soils bearing capacity, namely:

- Structural loads from the pump station will require to be born on the glacial till surface which is approximately 6m below the surface. This may require the installation of piles through the upper sand layers or through over excavation and backfill with an engineered fill.
- The foundation may need to be designed to withstand the additional forces due to soil structure interaction during a seismic event.
- The temporary excavations to install the pump station will take place on loose (and potentially saturated) sands. The report states it is unlikely that the excavation sidewalls can be graded back to a stable configuration. This would require the use of shoring or pile walls.
- The saturated loose sands below the surface and adjacent to the pump station location would be susceptible to liquefaction during a seismic event. This could result in loss of vertical bearing capacity for the pump station foundation, as well, this may impart substantial lateral loads on the pump station.
    - The presence of liquefiable soils at this site renders it a seismic site class "F" according to the BC Building Code 2012. As a result this would require addressing in the design to accommodate and mitigate the potential impact from these soils.

As the location would require extensive design and construction consideration we propose to move the location of Pump station 1 towards the waterfront to the north of Garrod RD on the east side of Bowser Rd. this will place the location within a known Archaeological Zone but may offer a more stable subsurface conditions in which to build the station.

This location will require a subsurface geotechnical investigation as well. As it is in a known Arch. Zone we will require the proper permitting and the presence of an archaeologist during the investigation. This is explained in further detail within section 6.2.

We have attached the Geotechnical Assessment in the appendix of this report for your reference/review.

7.0 RECOMMENDATIONS

Stantec recommends moving forward designing to the more realistic population buildout as discussed in this report. The sewer system design will utilize a gravity collection system feeding 3 pumping stations and will deliver the sewage to the WWTP via small diameter forcemain. By deviating from certain RDN and Bowser OCP guidelines, as mentioned in this report, the RDN is helping to maintain a realistic and well-functioning design. Stantec welcomes any feedback and suggestions the RDN may have towards moving into the detailed design stage and can incorporate or modify the design to suit them.

8.0 REFERENCES

The following were referenced in this report:

1. Chatwin Engineering Ltd. March 2011. Bowser Feasibility Study Sewer Servicing.

2. Statistics Canada. 2012. Deep Bay/Bowser, British Columbia (Code 590183) and British Columbia (Code 59) (table). Census Profile. 2011 Census. Statistics Canada Catalogue no. 98-316-XWE. Ottawa. Released October 24, 2012. http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/index.cfm?Lang=E (accessed February 16, 2016).

3. Regional District of Nanaimo. June 2008. Bowser Village Centre Plan

4. Regional District of Nanaimo. October 2015. Bylaw No. 500 Schedule 4D: Community Sewer System Standards.

Appendix B

Bowser Village Wastewater Service – Collection, Treatment and Disposal Preliminary Design – Marine Disposal, Revision A, March 9, 2016

202-2780 Veterans Memorial Parkway
Victoria, BC V9B 3S6
Phone: 778.433.2672
Web: www.greatpacific.ca
Email: gpinfo@greatpacific.ca

Bowser Village Centre Wastewater Service – Collection, Treatment Disposal

Stage I Environmental Impact Study – Marine Disposal

Attention:
Stantec Consulting Ltd.
400A – 2261 Keating Cross Rd
Victoria, BC V8M 2A5

March 9, 2016
1018-002
Rev A.

Disclaimer

GreatPacific Consulting Ltd. (GPC) has prepared this Report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professional current practicing under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this Report. No other warranty and/or guarantee, whether expressed or implied is made, with respect to the Report, the Information, or any part thereof.

This Report has been prepared for the specific project and/or site, design objective, development and purposes described to GPC by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this Report and are not applicable to any other project or site location. GPC accepts no responsibility for any events or circumstances that may have occurred since the date on which the Report was prepared and, in the case of subsurface, marine, environmental or geotechnical conditions, is not responsible for any variability in such conditions, geographically or over time.

Except as agreed to in writing by GPC and our Client or as required by law; or to the extent used by governmental reviewing agencies for the purpose of obtaining permits or approvals, the Report and the Information may be used and relied upon only by the Client and no other party without the express written consent of GPC and payment of compensation for that consent

Executive Summary

The Regional District of Nanaimo (RDN) is studying the potential of community wastewater collection, treatment and disposal in Bowser Village Centre. The wastewater system will be required to accommodate the project growth of the community form an estimated population of 170 to 889 in the year 2030.

This environmental impact study is intended to inform the design process for siting a new marine outfall by fulfilling the Stage I requirements of the *Municipal Wastewater Regulation* for a discharge to open marine waters. This report is based on desktop information only. It provides preliminary recommendations for wastewater treatment effluent quality, and for pre-discharge receiving environment monitoring. A Stage II environmental impact study will be needed in the future that involves the collection and analysis of site specific field data.

A treatment system is proposed for the Village of Bowser for an estimated average dry weather flow rate for the year 2030 of 320 m^3/day. Effluent from the treatment plant will be discharged to the Strait of Georgia, via a marine outfall.

Physical oceanographic properties of the Strait of Georgia were investigated to predict the dilution and path of the effluent plume in the receiving environment. Water column densities (dependent on the temperature and salinity) will be most stratified during the spring and summer, coinciding with the peak freshet from the Fraser River. Winter conditions are anticipated to be more consistent (less stratified) with depth. Current speed is expected to be less than 0.2 m/s with dominant directions parallel to the shoreline depending on the tidal conditions.

The site is exposed to south east and wind generated waves have the potential to exceed a height of 1.8 m. The proposed point of discharge will be at depth, below the influence of waves, however the outfall will need to be sufficiently protected from damage in the intertidal and shallow subtidal zone.

The marine waters fronting Bowser Village are productive with valued fisheries (both commercial and recreational) and supporting habitats.

A summary of valued fisheries components includes:

- Intertidal and subtidal bivalve shellfish, including aquaculture;
- Herring spawning grounds; and,
- Eelgrass beds.

A summary of valued recreational components includes:

- Beach wading/swimming
- Kayaking and boating

In order to meet the requirements of the MWR, the point of discharge will need to be a minimum of 400 m from shellfish waters. Feasible locations in the proximity to Bowser for a marine outfall are limited to either side of the BCHydro marine right of way.

Dilution modelling of the effluent plume was completed for the proposed discharge. Modelling results predict that a minimum dilution of 282:1 at the boundary of the IDZ will be acheived.

Based on the effective dilution of microbiological indicators and viruses in the effluent plume, effluent fecal coliform concentrations should be less than 7,000 MPN/100 mL to achieve shellfish water quality guidelines at the boundary of shellfish harvesting waters.

Table of Contents

Tables

Figures

1 Introduction

The Regional District of Nanaimo is studying the potential of community wastewater collection, treatment and disposal in Bowser Village Centre. The wastewater system will be required to accommodate the project growth of the community from an estimated population of 170 to 889 in the year 2030.

This Stage I Environmental Impact Study (EIS) is based on desktop information and is intended to inform the design process for siting a new marine outfall. In relation to the *Municipal Wastewater Regulation*, it investigates effluent disposal to the marine environment in proximity to Bowser Village, and the potential environmental impacts of the discharge.

1.1 Scope of Work

The scope of work for the study is based on the *Environmental Impact Study Guideline – A companion Document to the Municipal Wastewater Regulation* (MELP, 2000). The outfall is projected to discharge a maximum of 640 m^3/d into the open marine environment.

The specific objectives of the EIS include:

1. Identify maximum daily and average annual effluent flow;
2. Identify influent and effluent sewage quality: BOD_5, TSS, Total P, NH_3, metals, and fecal coliform levels;
3. Identify source control measures, as appropriate;
4. Locate on a marine chart or topographical map (1:50,000 or larger scale) and suitable larger scale site plan, the general location of the proposed discharge;
5. Identify any existing or proposed nearby discharges, including their quantity and quality;
6. Inventory receiving water uses, fisheries resources, commercial and shellfish leases, drinking water, recreational uses, irrigation, livestock watering, or other uses. Illustrate these uses on the marine chart or topographical map and site plan. Indicate applicable water quality guidelines;
7. Determine outfall depth/distance requirement using schedule 7, appendix 2;
8. Identify normal wind direction, tidal influences and marine/stream currents;
9. Estimate the initial dilution and subsequent dilution, diffusion and dispersion that will occur from the outfall diffuser, using worst-case values for seawater or stream temperature, pH, salinity and current or flows and effluent temperature and salinity;
10. Estimate the water quality at the edge of the IDZ and at any areas of concern (shellfish areas, beaches, water intakes, or others) for various treatment requirements (septic, primary, secondary as set out in schedule 3), using the most critical effluent quality parameters (e.g., NH_3 and fecal coliform levels), and compare these results with the water quality guidelines;
11. Based on the evaluation of the foregoing study task findings, recommend whether additional study tasks, including pre-discharge monitoring, are necessary;
12. Based on the evaluation of the foregoing study tasks findings, recommend the appropriate level of treatment and the optimum outfall location, depth and distance

combination to ensure that there are no adverse effects on human health and the environment;
13. Recommend a receiving environment monitoring program;
14. Summarize EIS findings and recommendations in a report with appropriate illustrations and supporting data and calculations

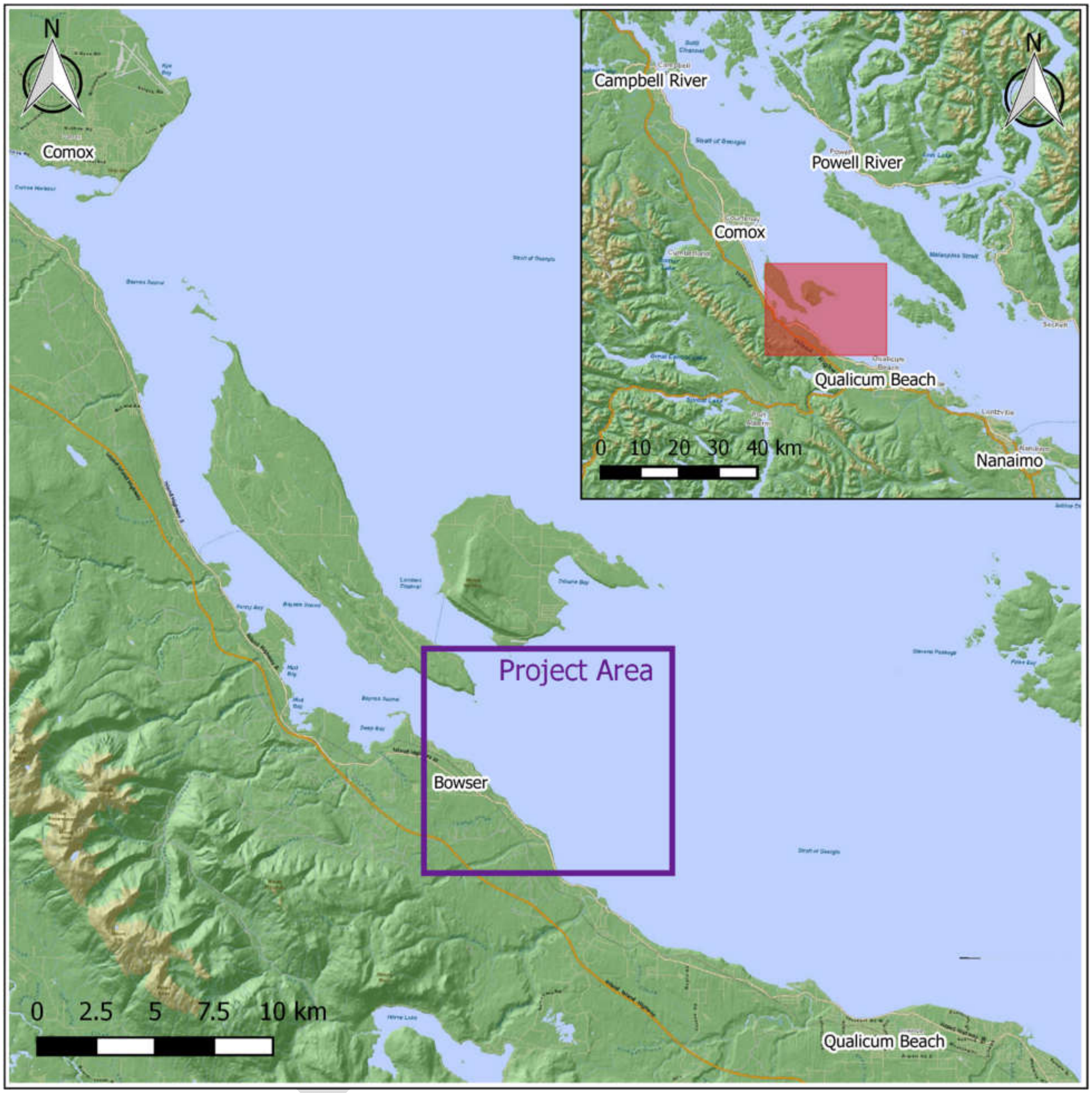
2 Study Area

Bowser Village is located on the east coast of Vancouver Island, north of Qualicum Beach, BC (Figure 1). The village is located within Electoral Area “H” of the Regional District of Nanaimo (RDN), approximately 20 km north-west of Qualicum Beach and 32 km south-east of Comox.

The northern portion of the Strait of Georgia is immediately east of Bowser Village. Baynes Sound separates Vancouver Island and Denman Island and Lambert Channel runs between Denman Island and Hornby Island, both to the north of the village. The Strait of Georgia is approximately 25 km wide between Bowser Village and Lasqueti Island, the closest island to the east.

Options for a marine outfall were investigated along approximately seven kilometers of shoreline fronting Bowser (from the mouth of Baynes Sound to Qualicum Bay).

Figure 1 Study Area



3 Regulatory Framework

3.1 Provincial and Federal Regulations

The key regulatory agencies and applicable regulations concerned with the discharge of municipal wastewater include:

- BC Ministry of Environment, *Environmental Management Act* and the associated *Municipal Wastewater Regulation* (MWR).
- Environment Canada, *Wastewater Systems Effluent Regulation* (WSER).

Provincial requirements for wastewater discharges are outlined in the MWR. The MWR regulates the minimum effluent quality and the outfall design criteria based on the properties of the receiving environment and effluent flow rates.

The proposed discharge is located in "open marine water". Open marine water is defined in the MWR as waters located outside a line, less than 6 km long, drawn between any two points on a continuous coastline.

Minimum effluent criteria are specified for the discharge flows less than and greater than two times the average dry weather flow (ADWF), as outlined in Table 1 below.

Federally, the WSER establishes minimum effluent criteria for all discharges with flows greater than 10 m^3/d. There is no association with receiving environment characteristics under the WSER. The minimum effluent criteria for the WSER are also outlined in Table 1 below.

Table 1 Minimum Effluent Requirements

	MWR Criteria (Open Marine Waters[1])		WSER[1] Criteria
	Daily Flow < 2x ADWF	**Daily Flow ≥ 2x ADWF**	
Toxicity	Monitoring required [2]		
BOD_5 [3]	< 45 mg/L (maximum)	< 130 mg/L (maximum)	< 25 mg/L (average)
TSS [4]	< 45 mg/L (maximum)	< 130 mg/L (maximum)	< 25 mg/L (average)
pH	6.0 - 9.0	n/a	
Total phosphorus (P)	n/a		
Ortho-phosphate as (P)	n/a		
Ammonia (as Nitrogen)	Based on receiving water characteristics [5]		1.25 mg/L (Un-Ionized maximum at 15˚C ± 1˚C)
Fecal Coliforms	Based on receiving water usage [6]		
Total Residual Chlorine	<0.02 mg/L (maximum)		<0.02 mg/L (average)

Notes:

1. Open Marine Waters is defined in the MWR as “marine waters other than embayed marine waters”. Embayed Marine Water is defined in the MWR as “marine water; (a) located within a bay from which the access to the sea, by any route, has a maximum width of less than 1.5 km, (b) located, if a line less than 6 km long is drawn between any 2 points on a continuous coastline, on the shore side of the line, or (c) in which flushing action is identified in a notice given by a director to be inadequate”. The proposed point of discharge is outside a line less than 6 km long (see Figure 1) and flushing is considered to be sufficient; therefore, the discharge will be into Open Marine Waters.

2. The discharge must monitor the toxicity of the effluent in accordance with the 96 hour LC50 bioassay test as defined by Environment Canada's Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout, (Reference Method, EPS 1/RM/13), and if applicable Environment Canada’s Procedure for pH Stabilization During the Testing of Acute Lethality of Wastewater Effluent to Rainbow Trout (Reference Method EPS 1/RM/50).

3. BOD_5 means the carbonaceous 5-day biochemical oxygen demand.

4. TSS means the total suspended solids or non-filterable residue.

5. Effluent standards for ammonia nitrogen are based on the predicted dilution within the effluent plume at the boundary of the IDZ. The IDZ is defined in the MWR as a cylindrical volume of water centered on the terminus of the outfall with a radius that is the lesser of 100 m or 25% of the width of the body of water; the cylinder extends from the seafloor to the surface of the water

   The allowable ammonia nitrogen concentration is based on back calculations of water quality guidelines and the predicted dilution of the effluent plume at the boundary of the IDZ. The most stringent water quality guideline, for the proposed discharge, is the average 5-to-30-day concentration of total ammonia nitrogen for the protection of marine life (MOE, 2001). The applicable guideline is based on a pH of 8.4 (MOE, 2001), a minimum salinity of 20 g/kg, and a maximum temperature of 15°C. In this case, the most stringent water quality guideline for ammonia nitrogen at the edge of the IDZ is 0.59 mg/L.

6. The allowable effluent fecal coliform concentration is back calculated from the predicted dilution at the boundary of the IDZ and any sensitive areas, and is based on the allowable fecal coliform concentration for these areas. The allowable fecal coliform concentration is dependent on the water based activities in the area of the discharge.

   For discharges to recreational use waters, the applicable water quality standard states that the number of fecal coliform organisms outside the IDZ must be less than 200 MPN /100 mL. Recreational usage is considered as “…any activity involving the intentional immersion or incidental immersion in natural waters”. Primary contact includes activities where the face and truck are frequency immersed or wetted by spray (e.g. waterskiing). Secondary contact includes activities where only the limbs are regularly wetted and immersion is unusual (e.g. fishing) (Health and Welfare Canada, 2012).

   For discharges to shellfish bearing waters the applicable water quality standard is median or geometric mean of less than 14 MPN/100 mL at the edge of the IDZ (Canadian Food Inspection Agency, 2013), with not more than 10% of the samples exceeding 43 MPN/100 mL. For the purpose of this regulation, shellfish water means water bodies that “have or could have sufficient shellfish quantities that recreational or commercial harvesting would take place or water for which commercial shellfish leases have been issued” (British Columbia, 2012). Shellfish are defined as: “all edible species of oysters, clams, mussels and scallops either shucked, in the shell, fresh or fresh frozen or whole or in part. For the purposes of marine biotoxin control, predatory gastropod molluscs shall also be included” (Canadian Food Inspection Agency, 2013).

The MWR also specifies a number of engineering requirements specific for outfalls. Applicable requirements relating to the existing outfall include:

- the IDZ must not extend closer to shore than the mean low water mark;
- the IDZ must be located at least 300 m away from sensitive areas such as; recreational areas, aboriginal, commercial or recreational shellfish areas, domestic water intakes, agricultural water intakes, or any other sensitive area requiring protection as identified by a director;
- the outfall diffuser must be designed and located at a sufficient depth to maximize the frequency that trapping of the effluent occurs;
- the outfall diffuser is located to intercept the predominant current and avoid small currents that tend to move towards shore;
- depth and distance of the terminus are to be determined by an EIS and computer modelling of the discharge (but a minimum depth of 10 m below mean low water in marine waters);
- a minimum 10:1 initial dilution must be attained at the boundary of the IDZ through the use of a diffuser;
- outside the IDZ, the discharge does not cause water quality parameters to exceed water quality guidelines;
- the outfall is located such that it is protected from wave, boat and marine activity

4 Wastewater Treatment System

Presently treatment technologies are being investigated by Stantec Consulting Ltd.. The proposed wastewater treatment system will be designed to meet the effluent quality standards of the MWR and WSER as described in Section 3. Disinfection requirements for the proposed treatment system are discussed in more detail in Section 8. The treatment plant will accommodate the estimated population and effluent flow rates detailed in Table 2.

Table 2 Design Basis Population and Flow Information (Stantec 2015)

Parameter	Phase 1 Year 2020	Phase 2 Year 2030
Population	445	890
Average Dry Weather Flow (m^3/d)	160	320
Maximum Month Flow (m^3/d)	200	400
Maximum Day Flow (m^3/d)	320	640
Peak Hour Flow (L/s)	6.6	13.3

4.1 Source Control and Inflow Infiltration

The wastewater collection system will be designed to accommodate flow up to two times the average dry weather flow. The collection system will be constructed in conjunction with the proposed wastewater treatment system. Inflow and infiltration to the collection system is therefore not anticipated to be significant.

5 Receiving Environmental Characteristics – Proposed Marine Discharge

The physical oceanographic characteristics of the receiving environment dictate the dilution, dispersion and potential impacts of an effluent plume discharged into the marine environment.

Primarily, the circulation patterns (current) and water column density impact the rate of dilution and path of the effluent plume to potential receptors of concern.

The following sections outline the key oceanographic properties in the vicinity of the discharge based on current reference material.

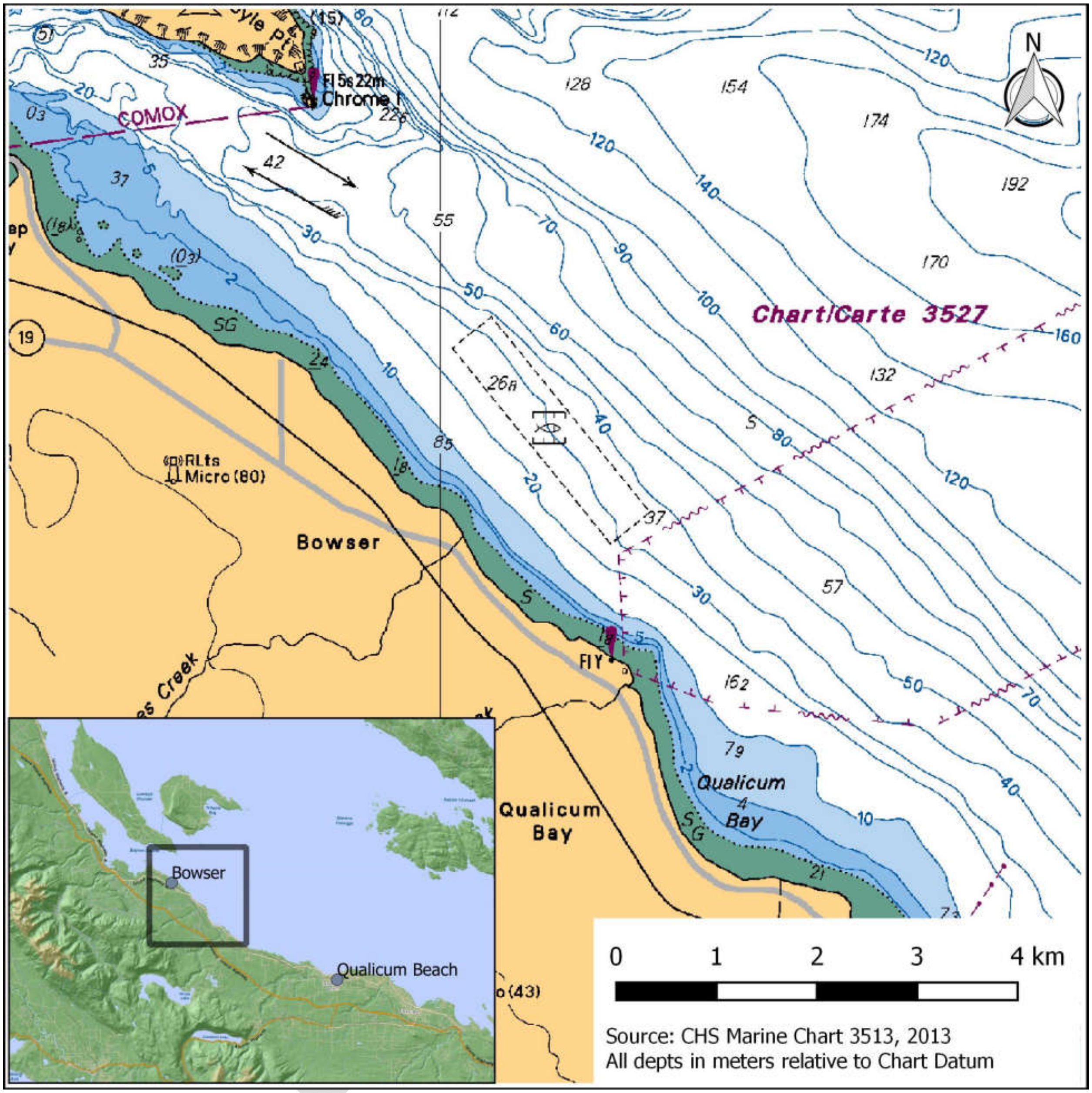
5.1 General Site Characteristics and Bathymetry

Bowser is located along the east coast of Vancouver Island, British Columbia, within the Strait of Georgia. The general bathymetry (seabed depths) within the study area is shown in Figure 2.

For marine discharges the minimum allowable depth of discharge is 10 m (British Columbia, 2012). The distance from the high water mark to the 10 m contour (light blue) ranges from approximately 500 to 1,000 m depending on the location. Further offshore, depth contours are parallel to the shoreline with depths of 50 m approximately 2 km offshore.

.

Figure 2 Bathymetry



5.2 Exiting Nearby Discharges

The Ministry of Environment authorization database (Ministry of Environment, 2015) was queried for the nearby discharges that may result in combined effects with the proposed discharge. No Marine discharges were identified within the study area.

A marine pipeline is shown on the marine chart for (CHS 2013) south of Qualicum Bay. The pipeline is likely a water intake and/or discharge for the Island Scallops hatchery located in Qualicum Bay.

5.3 Climate Normals

The temperature and precipitation climate normal data are provided in Table 3, measured at the Big Qualicum Hatchery in Bay Qualicum Bay approximately 6 km south east from the village of Bowser (Environment Canada, 2014a).

Table 3 1981 to 2010 Canadian Climate Normals at Qualicum Bay

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average Temperature (°C)	3.9	4.2	5.9	8.6	12.0	14.9	17.1	16.7	13.6	9.2	5.6	3.5	9.6
Precipitation (mm)	211	140	121	79	51	45	26	35	46	147	218	190	1309

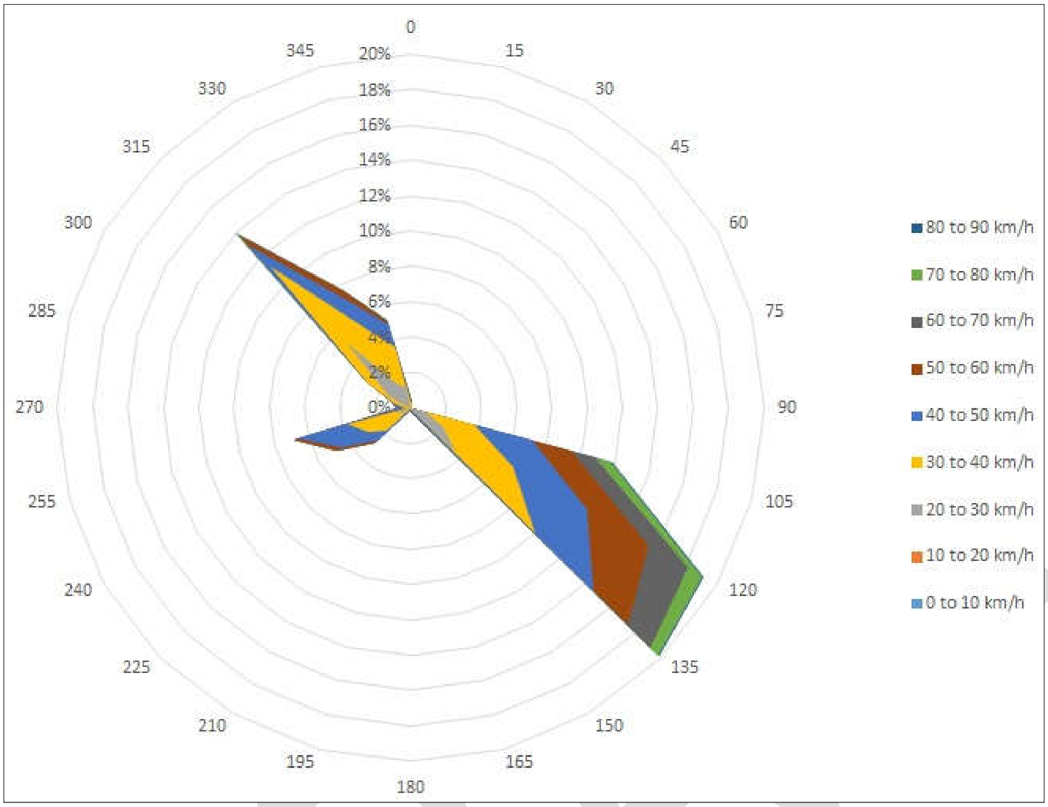
The nearest wind speed climate normal data was available at Comox Airport, approximately 35km north from Bowser (Environment Canada 2014b, Table 4) and Sisters Islets 17 km east of Bowser (Environment Canada 2015). The values at these two sites are expected to be reasonably consistent with the location of the proposed outfall.

Table 4 1981 to 2010 Wind Normals at Comox Airport

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Wind													
Speed (km/h)	13.6	12.6	13.8	13.2	12.4	12.4	12.4	11.3	10.5	12.2	14.3	14.1	12.7
Most Frequent Direction	SE	SE	SE	SE	SE	NW	NW	NW	NW	SE	SE	SE	SE
Maximum Hourly Speed (km/h)	77	84	81	72	63	64	56	56	64	70	93	81	93
Direction of Maximum Hourly Speed	SE	E	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE

Measured maximum daily winds at Sisters Islets between 2005 and 2015 are provided in Figure 3. The wind directions are consistent with those at Comox Airport with the predominant directions being northwest and southeast. The maximum wind speed of 70 to 80 km/h is from the southeast, though winds are less than 50 km/h approximately 80 % of the time.

Figure 3 Wind Rose at Sisters Island



The measured winds at Comox and Sister Islets correspond to prevailing wind patterns experienced in the Strait of Georgia. Winds are predominantly from the northwest in the summer and from the southeast in the winter (Thompson, 1981; Figure 4). The summer winds are associated both with large scale weather patterns (north pacific high) and local modification due to topography and sea/land breeze effects.

In the winter, the prevailing wind patterns may be altered significantly by polar outflow from the inlets along the eastern shores of the Strait. These outflow conditions can result in northwest wind through the northern portion of the Strait, instead of the typical southeast winter winds.

Figure 4 Prevailing Winds in the Strait of Georgia (Thompson, 1981)

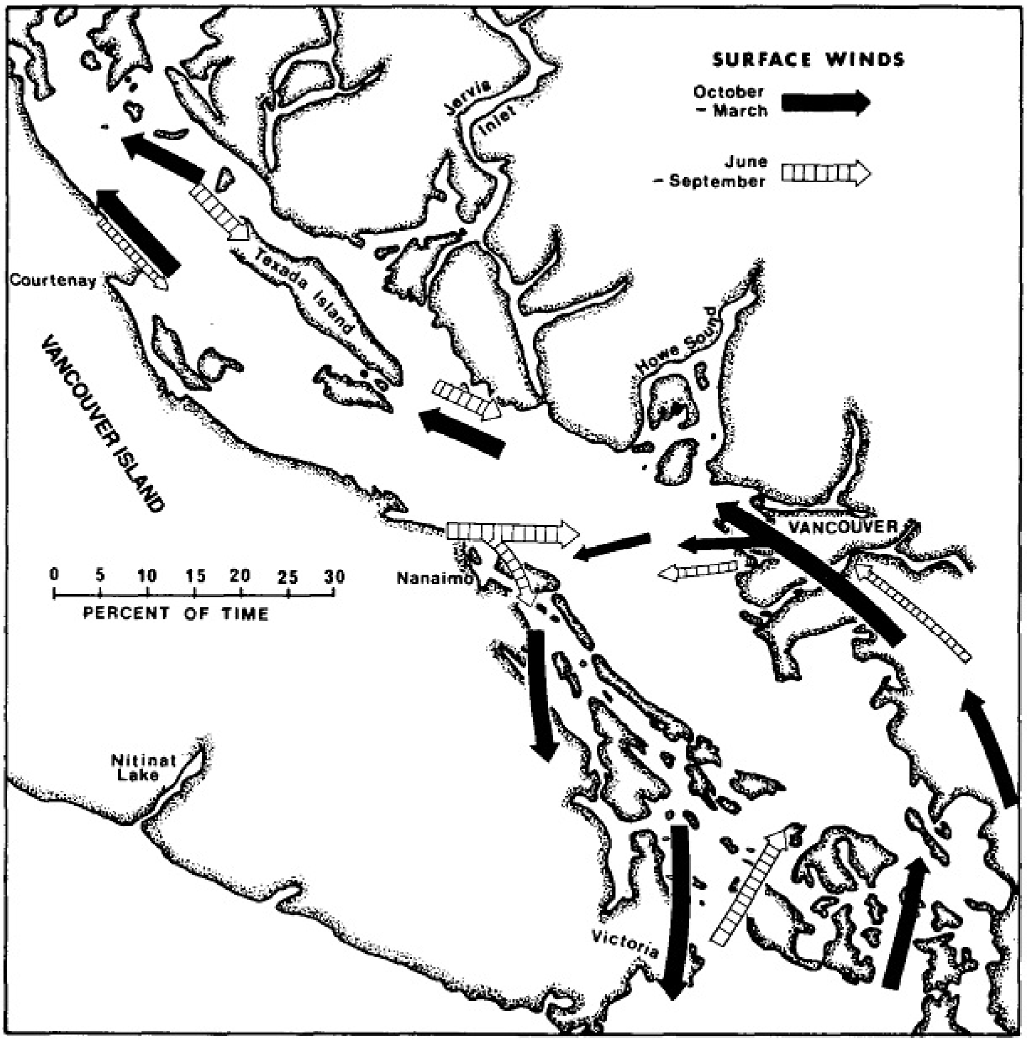


FIG. 10.5. Prevailing surface wind patterns over Strait of Georgia in winter (solid arrows) and summer (hatched arrows). Thick arrows correspond to speeds 4.5–9 m/s (8.7–17.5 kn); thin arrows less than 4.5 m/s. Comparison of length of arrow to scale on left yields frequency of occurrence of particular wind. (Modified after Barker 1974)

In relation to the proposed discharge, wind will tend to drive the surface currents and waves. In the summer, winds will drive currents to the southeast. Conversely, in the winter, the prevailing winds are more likely to result in current and waves towards the northwest.

5.3.1 Climate Change

Sea level rise has been projected at up to 0.8 m at Nanaimo by 2100 (British Columbia, 2008). An increase in water depth is unlikely to significantly impact the dilution performance of a marine outfall or the associated dispersion of the effluent plume. A greater water depth will increase the available water for dilution.

The increase in sea level will result in higher water levels along the shoreline and increased erosion potential. The onshore connection point and protection works associated with the outfall should take potential sea level rise into account.

5.4 Waves Heights

Wave heights in the vicinity of Bowser have not been specifically measured. Significant wave height (SWH) is measured in the Strait of Georgia by NOMAD buoy 46146 on Halibut Bank. Historical data from 1990-1999 indicate a mean significant wave height (SWH) of 0.42 m (Gower and McLaren, 2000). Variation in wave height within the Strait of Georgia is much less than off the west coast of Vancouver Island. Wave heights are limited by the fetch of the wind and by its strength and duration (Thompson, 1981). The total fetch from the north is limited by obstructions, like Denman and Hornby Islands. There is a fetch of approximately 100 km to the south east of Bowser to mainland British Columbia. The size of wave will be a function of wind speed and duration.

A maximum SWH of 1.87 m, with a period of 6.35 s was estimated based on the *Shore Protection Manual Volume II* (US Army Corps of Engineers, 1984). Wave conditions are not expected to significantly influence the dynamic of the effluent plume due to the depth of the discharge and the distance from the nearest shoreline where surf may occur. Wind induced waves are not considered further in the evaluation of plume behaviour.

5.5 Tide Conditions

The typical tide range for Hornby Island, the closest station to Bowser, is provided in Table 5 below. Tide elevations are provided relative to the local chart datum. The mean water level closely corresponds to geodetic elevations. The analysis herein was completed assuming the minimum water depth, this is considered a worst case condition, as there is the least volume of water above the diffuser and therefore the minimum potential for dilution.

Table 5 Tide Range at Hornby Island (DFO, 2008a)

Water Level		Water Elevation (m) above chart datum
Higher High Water	Large Tide	5.3
	Mean Tide	4.6
Mean (~ Geodetic)		3.2
Lower Low Water	Mean Tide	1.2
	Large Tide	0.0

5.6 Currents

The tidal exchange is the primary factor generating currents experienced throughout the Strait of Georgia. Currents in the vicinity of Bowser have not specifically been measured. In lieu of field measurements, the direction of the currents can be inferred from the *Sailing Directions* and

Current Atlas for the Strait of Georgia (DFO, 2008b; DFO, 2014). Currents are parallel to the coast during ebb and flood tides in the vicinity of Bowser. Currents flow to the northwest during flood tides and to the southeast during ebb tides.

Currents are reported to rotate from north to south and south to north during tide changes. Currents rotate away from the shoreline during the change from flood to ebb tides and towards the shoreline between ebb and flood tides.

Tidal induced current speeds are expected to be in the order of 0.1 to 0.2 m/s in the vicinity of the outfall. Wind induced waves and currents are likely to increase speeds near the surface; however, this is unlikely to influence the dynamics of the effluent plume that is trapped well below the surface.

5.7 Water Column Profiles (Density)

The density structure (stratification) of the receiving water column is a key variable in predicting the dilution that can be achieved when an effluent is discharged into the marine environment.

The effluent has a density close to that of fresh water prior to discharge and will be positively buoyant with respect to the surrounding seawater. The difference in density between the two fluids causes an effluent to float upwards when discharged into seawater at depth. At the point of release into the seawater, the effluent mixes with the seawater via the mechanics of turbulence and subsequently buoyant rise. The effluent / ambient seawater mixture (plume) rises towards the ocean surface due to the buoyancy flux resulting from the density difference between the plume and ambient seawater. As the plume rises, it entrains more ambient seawater, progressively increasing in density and approaches the temperature and salinity (density) of seawater.

If a density gradient (i.e. stratification) exists in the receiving environment surface waters, the density of the effluent plume may reach a depth where its density is equal to that of the overlying water. When this occurs, the effluent plume will no longer be buoyant and will cease its buoyant rise and will become "trapped". If little or no stratification is present, or insufficient entrainment has occurred, the effluent plume may continue to rise until it reaches the ocean surface.

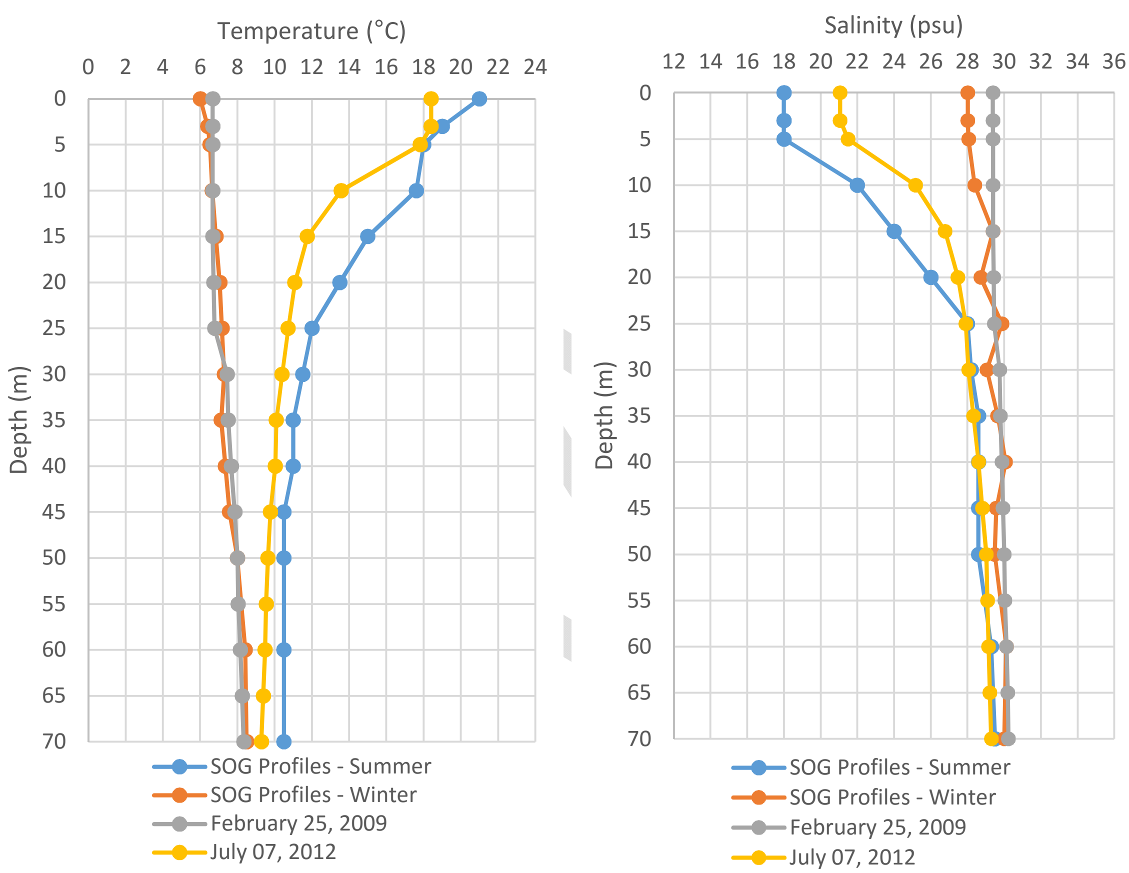
Therefore, the water column density properties were investigated to determine the range of stratification expected for the study area.

Water properties in the Strait of Georgia are dominated by the seasonal flow of the Fraser River. The Fraser River may discharge up to 15,000 m^3/s of fresh water into the Strait (WaterOffice, 2014). Peak flows in the Fraser River typically occur in the summer months from June to August. During this time, salinities in the top 10 m of the water column drop significantly in comparison to winter conditions. The range of expected temperature and salinities expected in the north Strait of Georgia were obtained from DFO (DFO, 2009). The maximum stratification expected in the region during the spring/summer freshet and the typical winter un-stratified conditions expected in the winter are plotted in Figure 5 as Strait of Georgia (SOG) profiles.

Localized profiles of temperature and salinity near the proposed point of discharge, during winter and summer, were requested from DFO (*pers.comm.* Andrew Lee, 2015). The localized profiles were reviewed for data collected within the two critical periods (spring freshet and winter conditions). Two profiles representative of the conditions measured in the Study area during these time periods are also presented in Figure 5.

The localized profiles are consistent with the anticipated range of temperatures and salinities for the Strait of Georgia. For dilution modelling purposes (Section 8), the maximum and minimum stratification conditions (SOG Summer and, February 2009) were modelled as "worst case" conditions at the proposed site.

Figure 5 Temperature and Salinity Profiles



6 Receptors and Water Uses

The main receptors of concern include sensitive areas, recreational areas and harvestable marine resources, particularly bivalve shellfish, where pathogens originating in the effluent plume may be concentrated and transferred to humans when consumed.

6.1 Wildlife Management and Sensitives Areas

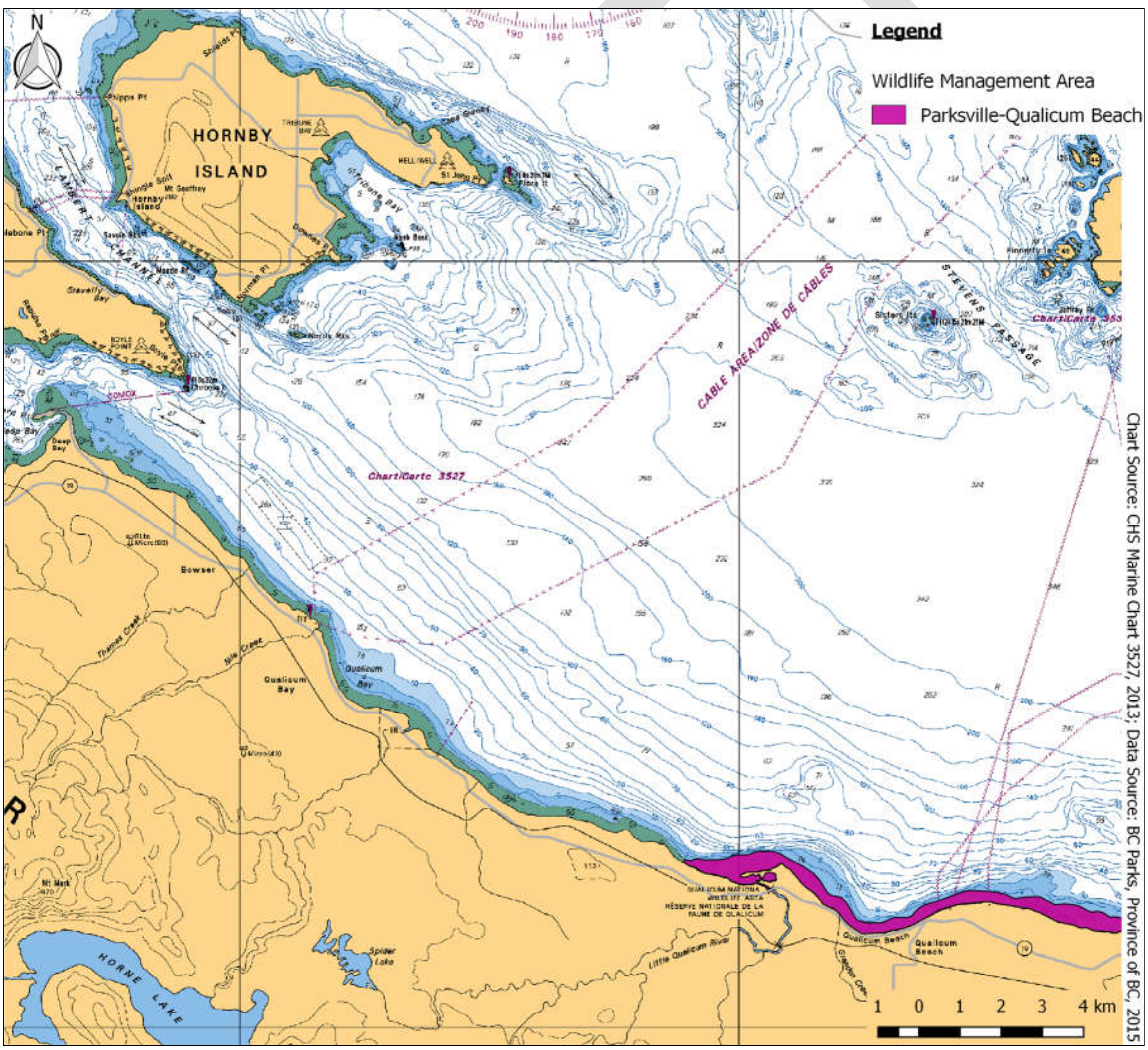
The proposed project area is located in proximity to Provincial Parks and Wildlife Management Areas.

6.1.1 Parksville-Qualicum Beach Wildlife Management Area

The Parksville-Qualicum Beach Wildlife Management Area (WMA) is in proximity to the project area (Figure 10). The 1,024 hectare WMA was designated in 1993 to conserve estuarine and foreshore habitats important to waterfowl and fish. The Parksville-Qualicum Beach WMA is a significant habitat on a global scale (FLNRO, 2015). The numerous estuaries, beaches, foreshore gravel bars, eelgrass beds and algal beds provide significant habitat for over 100,000 waterbirds. The foreshore provides vital rearing habitat for Pacific salmon, steelhead and cutthroat trout, and schools of herring that spawn there each year (FLNR, 2015).

The proposed marine outfall discharge location is unlikely to negatively impact the Wildlife Management Area, as it is located away from freshwater spawning grounds and from shallow nearshore marine rearing and foraging areas.

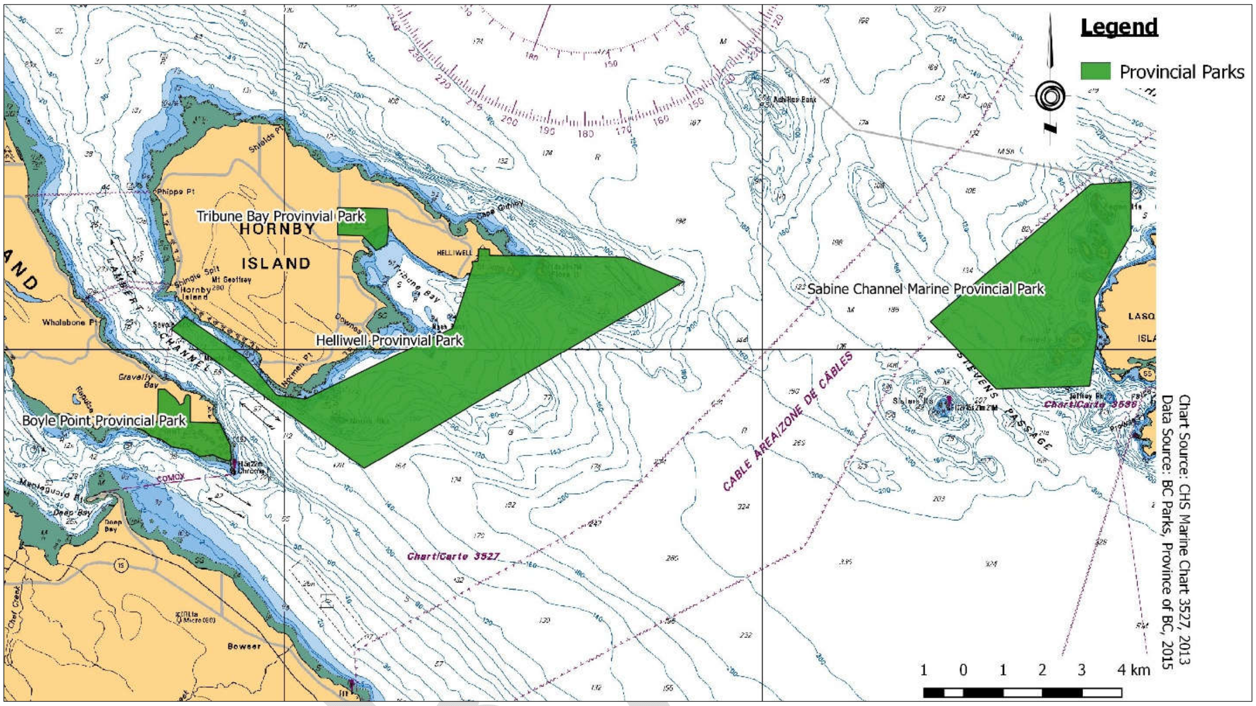
Figure 6 Parksville-Qualicum Beach Wildlife Management Area



6.1.2 Provincial Parks and Marine Parks

There are numerous Provincial and Marine Parks in proximity to the study area. Figure 8 shows the Provincial Parks nearby. These will be taken into consideration when selecting the outfall alignment. The outfall terminus will be sited to avoid provincial marine parks.

Figure 7 Provincial Parks and Provincial Marine Parks



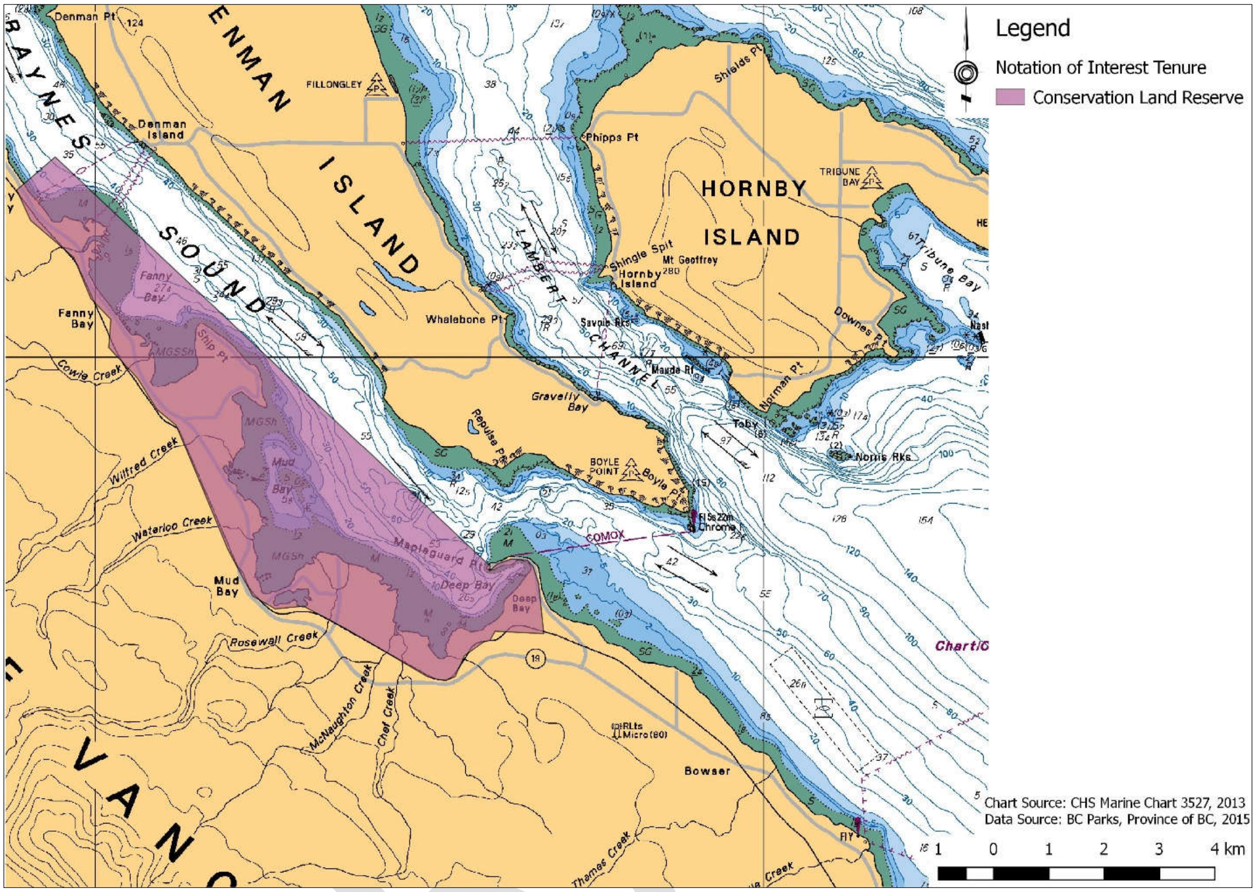
6.1.3 Tenures and Notation of Interest - Conservation Lands

A Reserve and Notation of Interest Tenure is located in Baynes Sound, southwest of the project area (Figure 9). It is designated as conservation land secured for fish and wildlife (BC, 2015a). A Notation of Interest Tenure can be obtained through Section 17 of the *Land Act*, which limits certain uses of the land. Section 17 is Conditional Withdrawal (or Designated Use Area), which states:

> *17 (1) The minister may, if the minister considers it advisable in the public interest, designate a portion of Crown land for a particular use or for the conservation of natural or heritage resources.*
>
> > *(1.1) The minister may impose any terms and conditions the minister considers necessary or advisable on the use of land designated under subsection (1).*
>
> *(2) A portion of Crown land designated under subsection (1) is withdrawn from disposition under this Act for any purpose that is not, in the opinion of the minister, compatible with the purpose for which the land has been designated.*
>
> *(3) The minister may amend or cancel a designation made under subsection (1)* (BC, 2015b).

The outfall will not be located within any conservation reserve tenures.

Figure 8 Notation of Interest Tenure – Conservation Land



6.2 Aquatic Resources

6.2.1 Shellfish

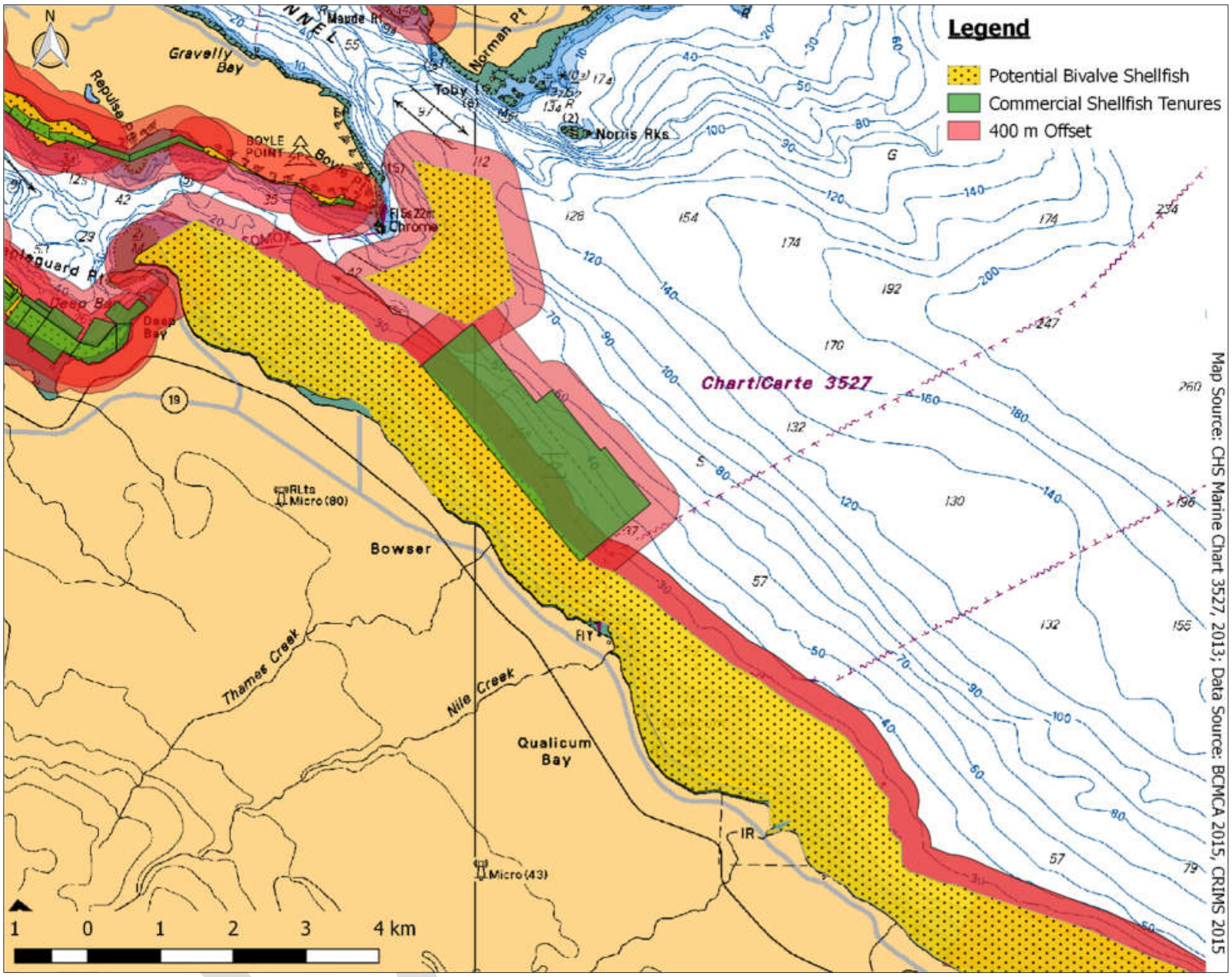
Bivalve Shellfish

As defined in the MWR, shellfish waters means "*bodies of water capable of supporting shellfish in quantities that permit aboriginal, commercial or recreational shellfish harvesting".*

The foreshore of Bowser and Qualicum Bay is known to be a highly productive bivalve area, making it an important area for fisheries. Known and probable intertidal and subtidal shellfish beds and shellfish tenures in the study area are shown in Figure 9. These include intertidal clams, subtidal bivalves (eg. Geoducks, scallops). Island Scallops Ltd. holds a shellfish aquaculture tenure and operates a scallop farm in the waters fronting Bowser.

A minimum offset of 400 m (100 m IDZ plus 300 setback) as described in section 3.1 is shown to indicate areas where discharge is prohibited. The proposed outfall terminus must be located in waters beyond the minimum offset (outside any of the shaded areas in Figure 9).

Figure 9 Bivalve Shellfish Locations



Sanitary Closures

Any given area may be closed to commercial bivalve shellfish harvesting for a variety of sanitary reasons. Fisheries and Oceans Canada identifies permanent bivalve fishing prohibited areas (no harvesting for any purpose) at the following locations:

- Within 300 m of industrial, municipal and sewage treatment plant outfall discharges;
- Within a minimum 125 m of marinas, wharves, finfish net pens, float homes or other floating living accommodation facilities, including live-aboard boats (DFO, 2014).

Bowser is located in Regional Area 14. There are presently no shellfish harvesting closures in the proposed project area.

6.2.2 Herring

Pacific herring (*Clupea pallasii*) is a pelagic species that inhabits the inshore and offshore waters of the North Pacific. There is a commercial fishery for herring in BC, they are fished for food, social and ceremonial purposes by First Nations, and they are an important forage fish for a number of other commercial harvested fish species.

Herring school in shallow vegetated inshore areas to spawn in the spring. Figure 10 shows the areas in which herring spawn near Qualicum Bay and Bowser. Figure 11 shows the areas around Denman Island where herring spawn. Bowser and southeast to Parksville is known to be vital herring spawning areas. The initial dilution zone for the outfall is proposed to be at a depth of 55 m, which is considered to be well offshore of significant herring spawn areas.

Figure 10 Herring Spawning Locations - Qualicum

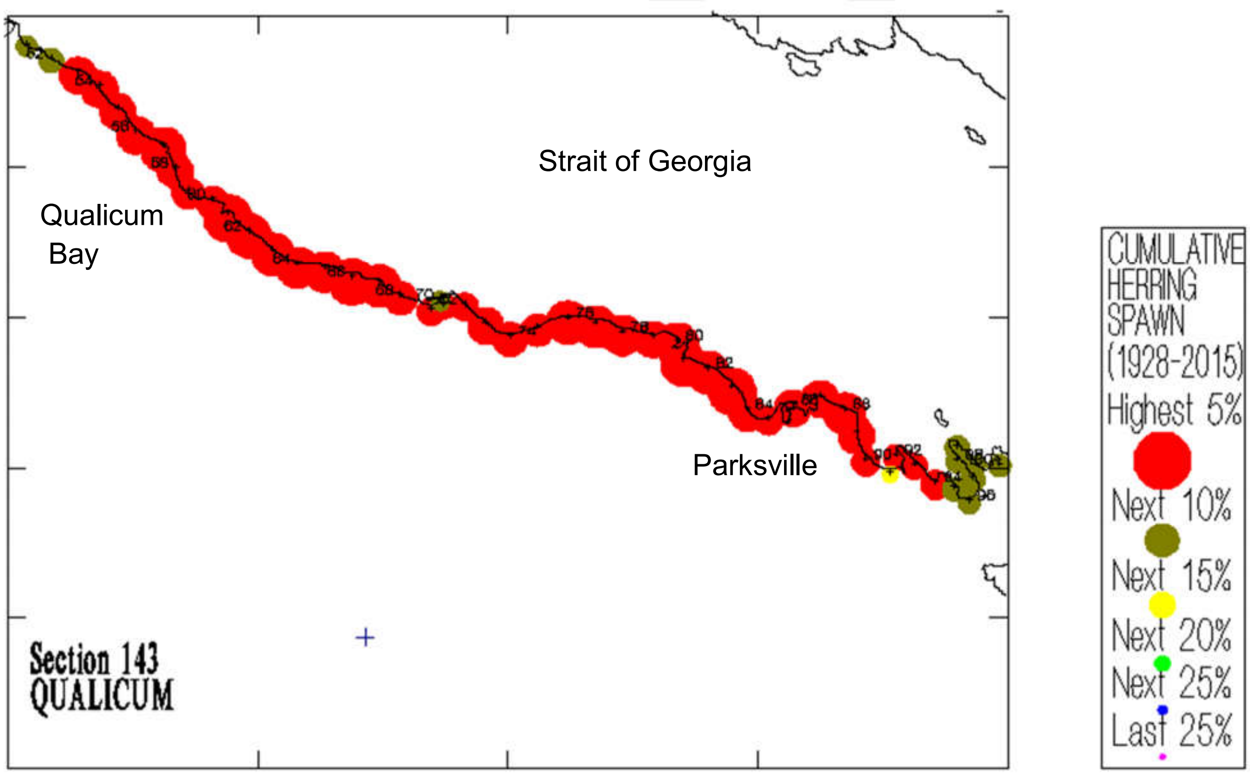
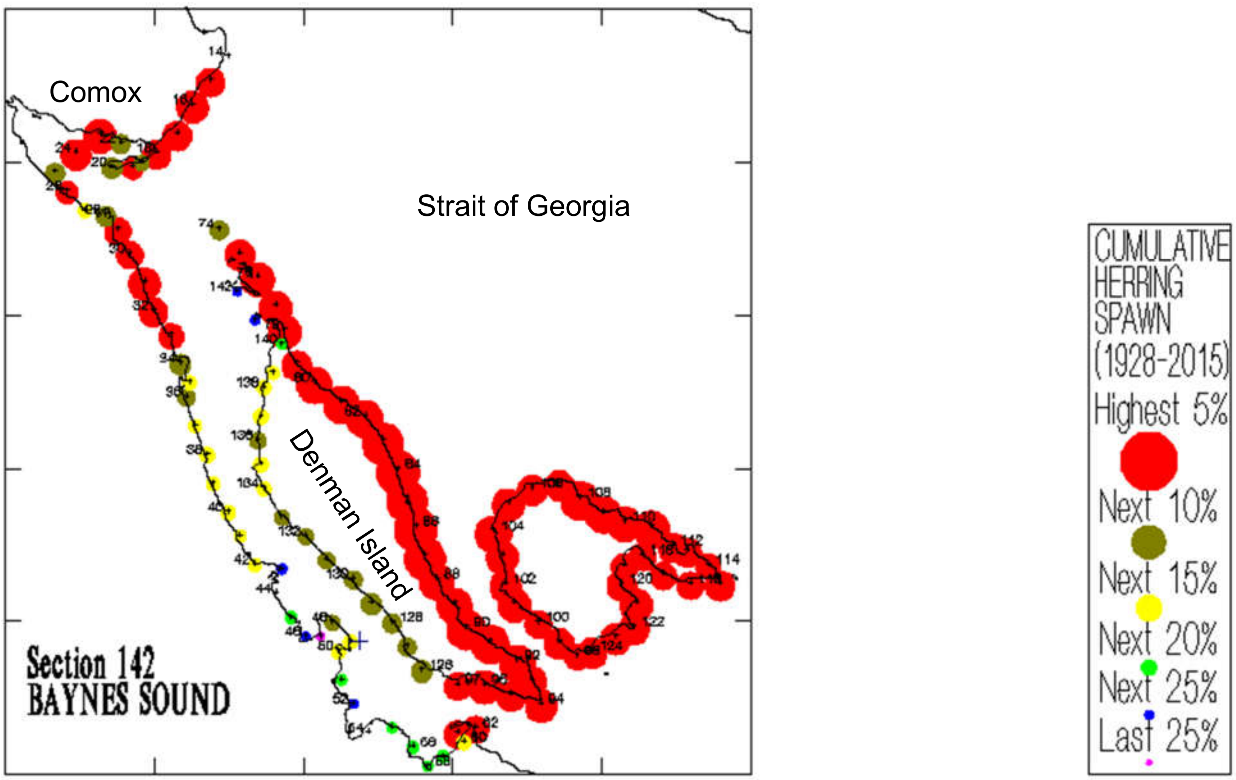


Figure 11 Herring Spawning Locations – Baynes Sound



6.2.3 Salmon

The Strait of Georgian region is defined as the area between the east and south-east coasts of Vancouver Island and British Columbia. There are dozens of inlets and river mouths in this area, many of which are used by salmon.

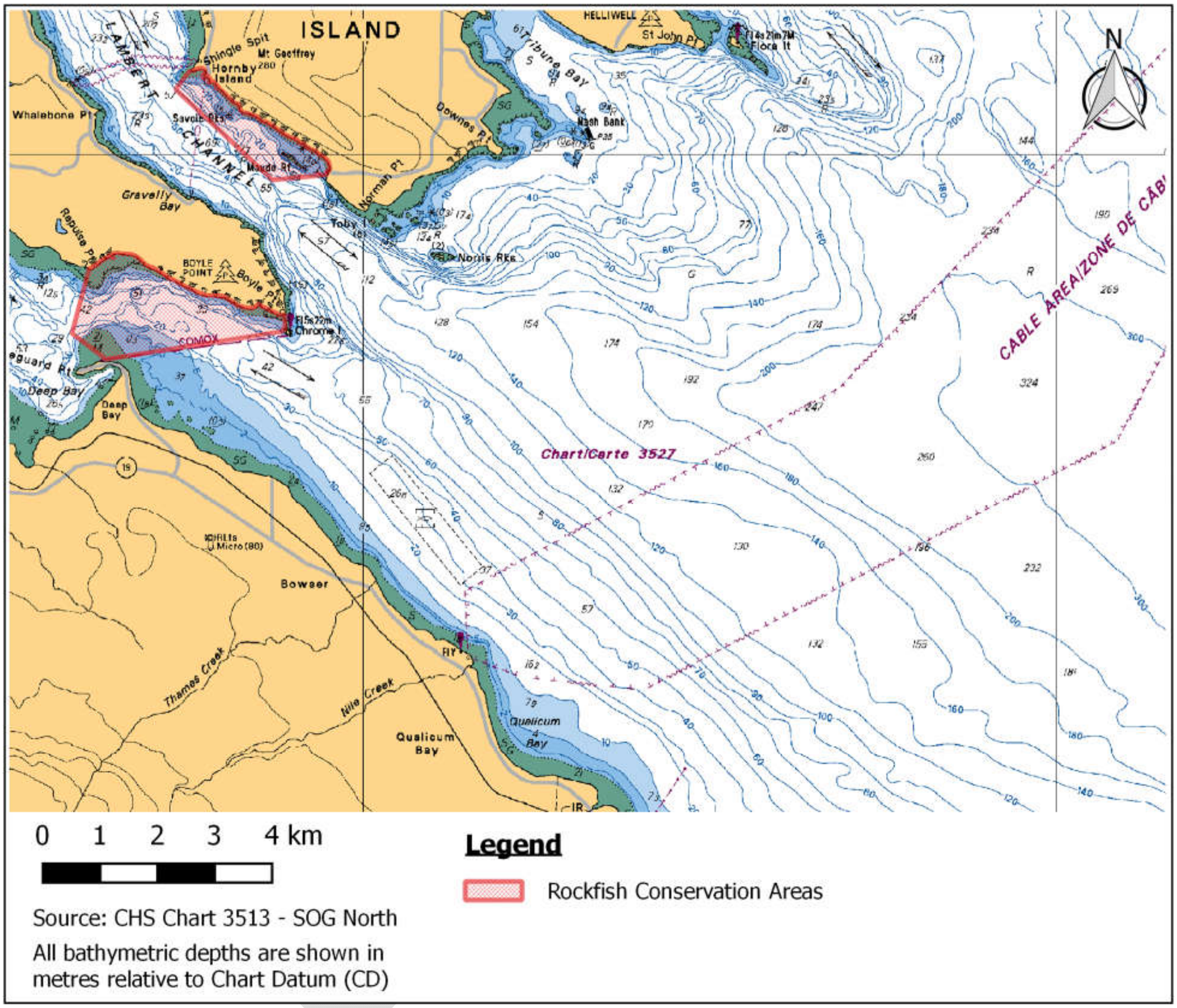
Qualicum River is a salmon bearing stream, supporting chinook, chum, pink and sockeye. Rosewall Creek, McNaughton Creek, Chef Creek, Cook Creek, Thames Creek, Sandy Creek and Nile Creek all are known to be used by chum and coho.

The proposed marine outfall discharge location is unlikely to negatively impact salmon as it is located away from freshwater spawning grounds and from shallow nearshore marine rearing and foraging areas.

6.2.4 Rockfish

There are 37 species of rockfish typically caught in fisheries in British Columbia. Inshore rockfish species include yelloweye, quillback, copper, china, and tiger. Rockfish are an important species for First Nations, commercial and recreational harvesters. Rockfish Conservation Areas (RCAs) have been established throughout the BC coast to mitigate low abundance and over fishing. Within RCAs, inshore rockfish are protected from recreational and commercial fisheries. There is one Rockfish Conservation Area approximately 5.6 km north of the proposed outfall (BCMCA, 2011; Figure 12). The proposed marine outfall discharge location is unlikely to negatively impact rockfish as the IDZ is located away from rockfish conservation areas.

Figure 12 Rockfish Conservation Area

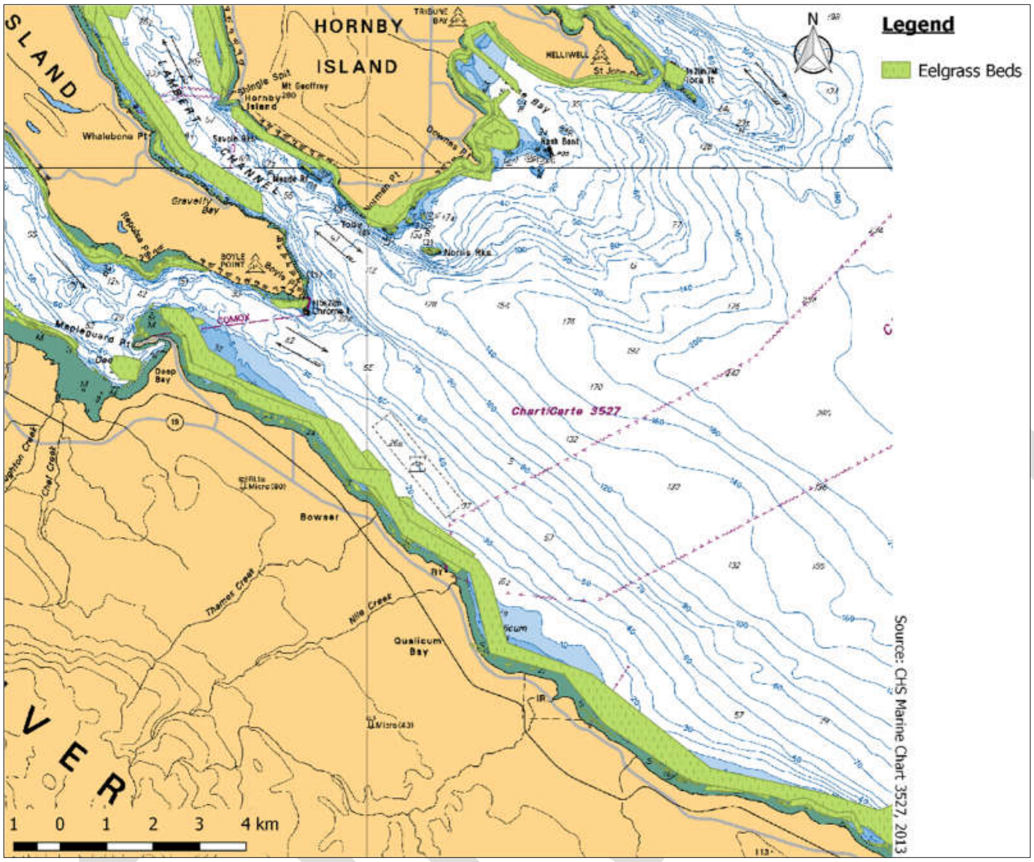


6.2.5 Aquatic Plants

Eelgrass communities are one of the most productive and vulnerable ecological communities of BC's coast. Eelgrass beds function like biodiverse aquatic nurseries and refuges for a range of species, as well as foraging grounds for numerous resident and migratory species (EC, 2002). Pacific herring lay their eggs on eelgrass. The foreshore of Bowser and the surrounding shorelines are some of the most important herring spawn areas in the province. Figure 13 shows the presence of eelgrass near the project location and surrounding area.

The proposed marine outfall discharge will be located in deep water, away from the shallow eelgrass beds. The outfall pipeline may need to be laid through areas with eelgrass, so the final alignment should be selected to minimize the interaction with eelgrass.

Figure 13 Eelgress Bed Locations



6.3 Marine Mammals

A number of marine mammals that are listed federally and/or provincially at risk have the potential of occurring, on occasion, in the Strait of Georgia. These species are listed in Table 6.

Table 6 Marine Mammals at Risk

Common Name	Scientific Name	Federal Status	BC Status
Killer whale (southern resident)	*Orcinus orca pop. 5*	Endangered	Red
Killer whale (West Coast transient)	*Orcinus orca pop. 3*	Threatened	Red
Grey whale	*Eschrichtius robustus*	Special Concern	Blue
Humpback whale	*Megaptera novaeangliae*	Special Concern	Blue
Stellar sea lion	*Eumetopias jubatus*	Special Concern	Blue
Harbour porpoise	*Phocoena phocoena*	Special Concern	Blue

The proposed outfall will not be located within critical habitat reported for the species listed in Table 6.

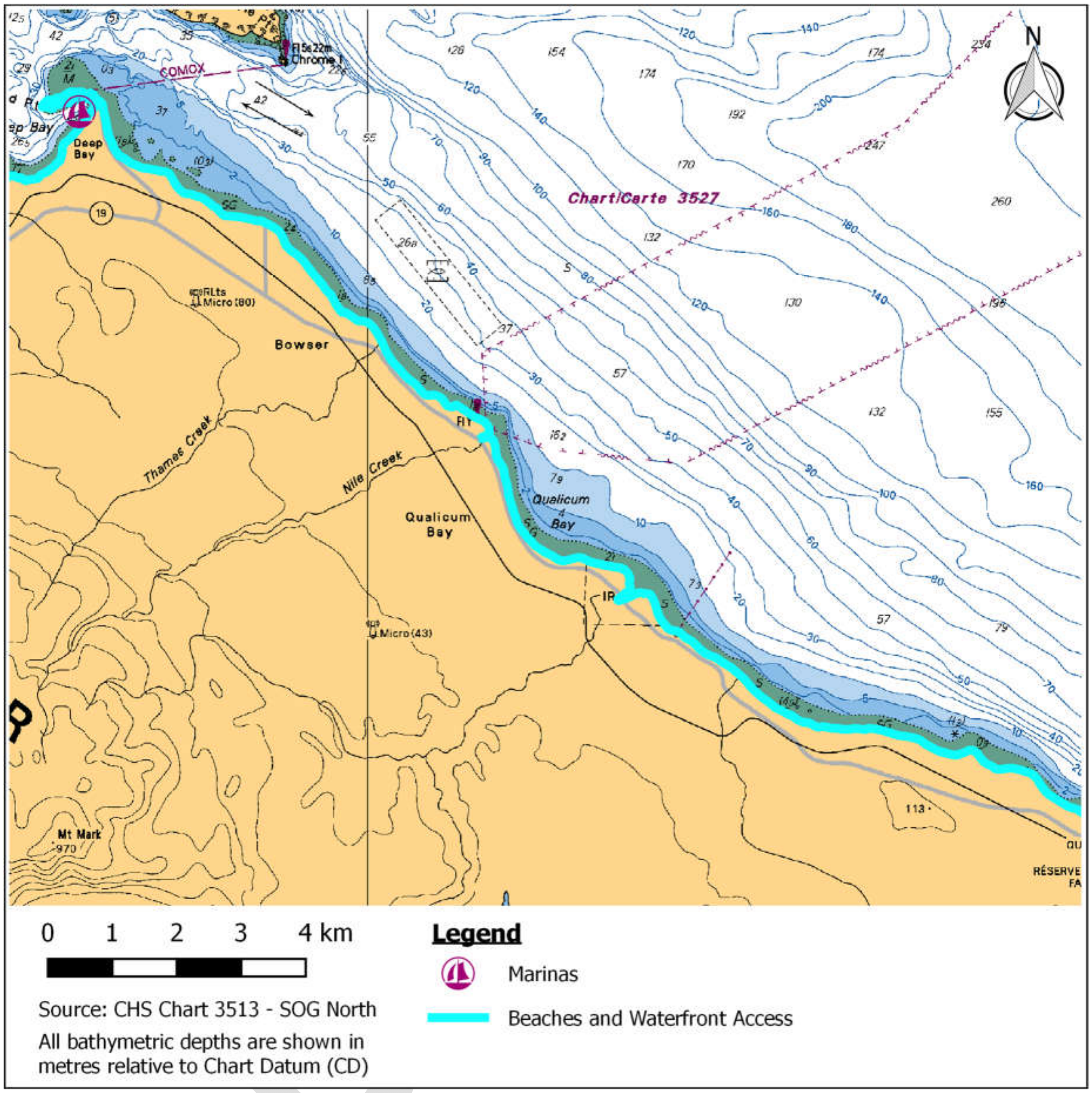
6.4 Recreational Use

6.4.1 Marinas and Waterfront Access

The waterfront at Bowser and southeast to Parksville is used for a variety of recreational activities such as beach wading/swimming, and kayaking. Figure 14 shows the points of access, as well as registered marinas in the area. The proposed marine outfall location is unlikely to negatively impact waterfront access and recreational activities.

Water quality guidelines for recreational waters are less restrictive than those for shellfish waters. Therefore, provided shellfish harvesting guidelines are achieved at shellfish waters, recreational activities will also be protected.

Figure 14 Marinas and Water Access



6.4.2 Fishing and Boating

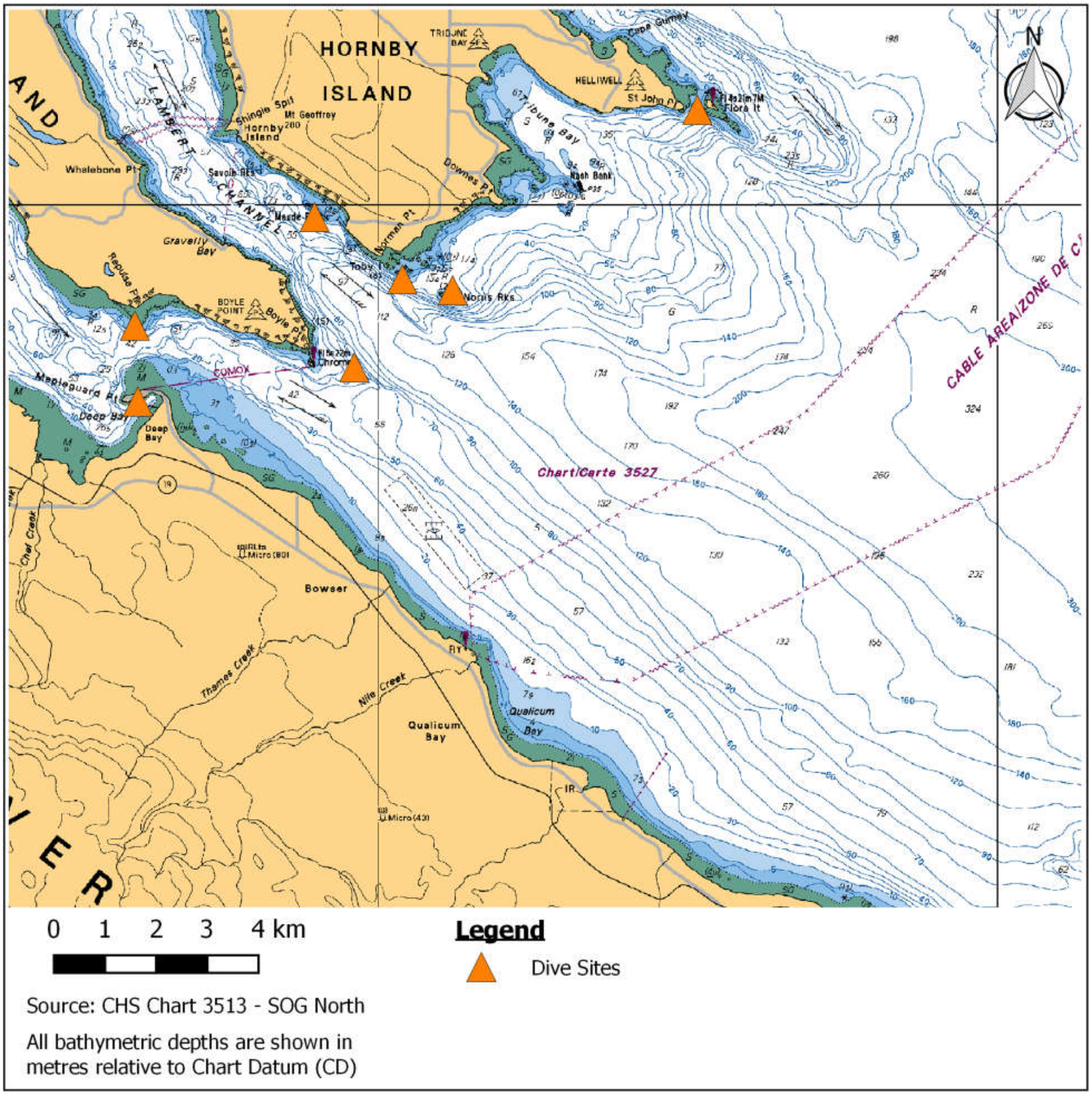
The project area, located in the Strait of Georgia, is used for fishing and boating. A variety of fish species inhabit the waters in which the project area is located, making it ideal for fishing charters, as well as commercial fishing. Deep Bay, Bowser, Qualicum and Parksville have numerous fishing charter businesses.

The outfall will not impede boating and the plume will be trapped deep below the water surface.

6.4.3 Diving

Figure 15 shows reported recreational dive sites in the area, as recognized by the British Columbia Marine Conservation Analysis (BCMCA, 2011). None of the dive sites are located near the proposed outfall.

Figure 15 Dive Sites



6.5 Other Significant Uses

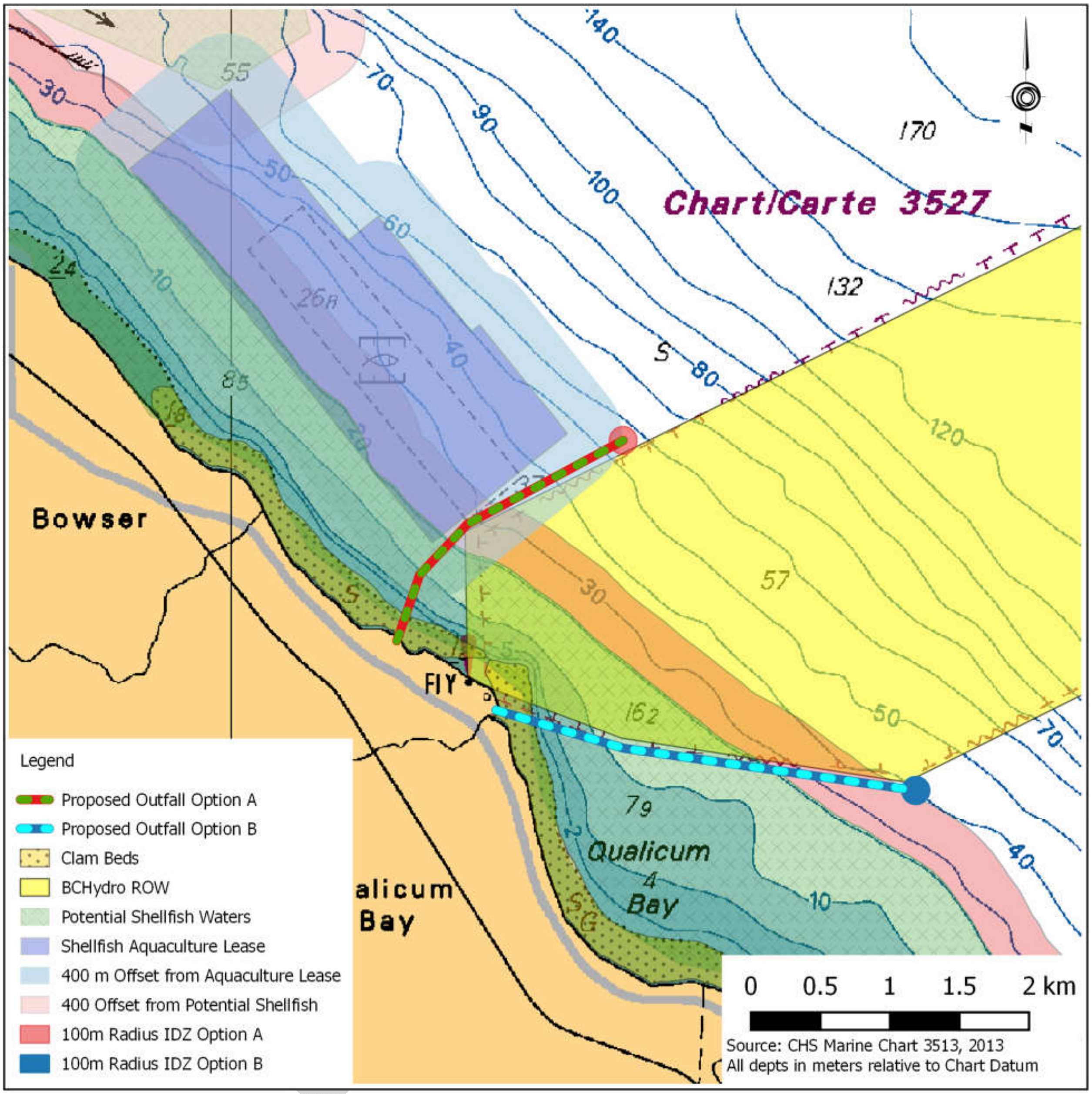
BC Hydro operates submarine transmission cables between Texada Island and Qualicum Bay. BC Hydro's existing right of way is shown in Figure 16. The proposed outfall should avoid conflicting with land tenures.

7 Outfall Siting

Based on the constraints discussed in the previous sections, potential discharge locations are limited to areas outside those shaded in Figure 16. There are essentially no suitable points of discharge north of the aquaculture lease.

The terminus would be 400 m from the closest shellfish harvesting areas. The alignments shown assumes that the outfall would utilize existing road ROW and beach accesses.

Figure 16 Suitable Discharge Zones and Proposed Outfalls



7.1.1 Depth and Distance Calculation

The depth and distance of the outfall must conform to the requirements of section 100 (1) of the MWR. The outfall must meet the following requirements:

For discharges of less than 5,000 m^3/d, the calculated critical flow must be greater than or equal to the maximum daily flow (m^3/d), with the calculated critical flow being the greater positive value of:

15. (D1 + 0.075D2 – 21) / 0.0029, and
16. (D1 +0.075D2 –12.225) / 0.025;

Where:

"D1" means the depth (m) of the shallowest diffuser port below mean low water; and,
"D2" means the distance (m) to the closest port of the diffuser from mean low water.

For the proposed discharge the most conservative conditions (D1 = 40 m depth and D2 = 2,200 m length)

The critical flow for the proposed discharge is 63,000 m^3/d. The average dry weather flow (320 m^3/d) is well below the critical flow and therefore the proposed outfall achieved this requirement.

8 Dilution Modelling

Preliminary dilution modeling was completed for the proposed Option A diffuser location. The purpose of the dilution modelling was to determine whether the proposed diffuser concept would provide sufficient dilution of the effluent plume to achieve applicable water quality guidelines.

The preliminary dilution modelling was completed using the following effluent properties and diffuser configurations (Table 10).

Table 7 Effluent Flow and Diffuser Configuration

Parameter	
Flow Rate **ADWF** **2 x ADWF**	 320 m^3/d 640 m^3/d
Diffuser Depth	55 m
Number of Ports	1
Port Diameter (effective diameter of Tideflex™ Valve)	0.064 mm or 0.076 mm
Vertical Discharge Angle	5° (above horizontal)
Horizontal Discharge Angle	90° (perpendicular to current)

8.1 Model Description

Dilution analysis was completed to predict the concentration of the effluent as it travels away from the outfall terminus during initial dilution and subsequent dispersion, and to predict the trapping depth of the effluent plume. Modelling was conducted using the USEPA computer modelling package called Visual Plumes, which is recommended by the BC MOE (MELP 2000). The Visual Plumes model predicts the dilution of the effluent plume during its initial dilution and subsequent dispersion. The initial dilution of the effluent plume is predicted by the UM3 model within Visual Plumes which is based on the UM model (Baumgartner *et al.* 1979).

The initial dilution of the effluent plume occurs as a result of the dissipation of momentum and energy immediately after discharge and the entrainment associated with the buoyant rise of the effluent plume. The effluent plume will continue to rise until the density of the effluent plume reaches that of the surrounding water. The depth where this occurs is referred to as the "trapping depth". Subsequent dispersion refers to the reduction in concentration as the effluent mixes with the receiving environment through ambient turbulence as current moves the plume laterally.

The effluent plume was modeled to estimate the minimum dilution and the shallowest trapping depth, which are considered to be the two "worst case results" for marine discharges.

Ambient Conditions

The effluent plume was modelled for a total of six specific ambient conditions. These included two water column temperature and salinity profiles representing summer and winter conditions as discussed in Section 5.7. For each season three ambient current scenarios were modelled. For each scenario, current speeds are defined for both nearfield (initial dilution) and far field. The three scenarios included:

- Low current (0.02 m/s) in both the near and far field. This represents slack tide conditions, occurring during the change from ebb to a flood or vice versa.
- High current (0.20 m/s) in both the near and far field. This represents peak flood or ebb current speeds.
- Low current (0.02 m/s) in the near field and high (0.20 m/s) in the far field. This represents a discharge at slack tide followed by an increase in current speed as the tidal exchange strengthens.

8.2 Results

Results of dilution modelling are provided in Table 8 below. The predicted trapping depth of the effluent plume is provided along with predicted dilution of the effluent plume at the boundary of the 100 m radius Initial Dilution Zone (IDZ) as defined in the *Municipal Wastewater Regulation* (British Columbia, 2012)

Table 8 Dilution Modelling Results

Season	Discharge Flow	320 m^3/d			640 m^3/d		
	Near Field Current (m/s)	**0.02**	**0.20**	**0.02**	**0.02**	**0.20**	**0.02**
	Far Field Current (m/s)	**0.02**	**0.20**	**0.20**	**0.02**	**0.20**	**0.20**
Summer	**Trapping Depth**	46	51	46	45	50	45
	Dilution @ 100 m	1723	2566	371	1148	1912	282
Winter	**Trapping Depth**	38	50	38	36	49	36
	Dilution @ 100 m	3298	3941	1005	2269	3037	798

For all scenarios modelled the effluent plume is predicted to remain trapped below a depth of 36 m. The worst case in terms of trapping depth occurs with low current seeds (slack tide) and in the winter with limited water column stratification.

The worst case dilution of the effluent plume is 282:1 at the boundary of the initial dilution zone, which achieves the minimum required dilution of 10:1 (defined in the MWR). The worst dilution case is predicted when the effluent plume is discharged during slack tide and then the current speeds increase as the flood or the ebb tide commences. This minimum dilution is only anticipated to occur for short periods of time (less than half an hour) following the slack tides (i.e. four times a day). The majority of time, dilutions are predicted to exceed 1,000:1.

The minimum dilution predicted at the boundary of the IDZ (282:1) was used to back calculate allowable ammonia concentration in the effluent based on applicable water quality guidelines.

The BC water quality guidelines for the protection of marine aquatic life (Ministry of Environment, 2014); for ammonia nitrogen is based on ambient temperatures, salinities and pH. Assuming conservative values of 20 °C (temperature), 10 ppt (salinity) and a pH of 8.0, the guideline for the average 5 to 30 day concentration is 0.97 mg/L and the guideline for the maximum concentration of ammonia is 6.4 mg/L.

Based on a dilution of 282:1 the effluent ammonia concentration should be less than 273 mg/L to achieve water quality guidelines at the boundary of the IDZ at all times.

Microbiological Indicators

Microbiological indicators were assessed independently from ammonia. The BC water quality criteria for microbiological indicators are provided in Table 2 below.

Table 9 BC Water Quality Criteria for Microbiological Indicators

Water Use	Escherichia coli	Enterococci	Fecal Coliforms
Shellfish harvesting	≤ 43/100 mL 90th percentile	≤ 11/100 mL 90th percentile	≤ 43/100 mL 90th percentile
Shellfish harvesting	≤ 14/100 mL median	≤ 4/100 mL median	≤ 14/100 mL median
Recreation - secondary contact - crustacean harvesting	≤ 385/100 mL geometric mean	≤ 100/100 mL geometric mean	None applicable
Recreation - primary contact	≤ 77/100 mL geometric mean	≤ 20/100 mL geometric mean	≤ 200/100 mL geometric mean

The water quality guideline for shellfish harvesting applies to marine waters used for the growing and harvesting of bivalve molluscs (clams, scallops, geoducks, etc.) for human consumption. Bivalve shellfish are filter feeders and may concentrate pathogens from the effluent plume within their intestines. The shellfish harvesting guidelines are applicable with respect to the proposed discharge.

Secondary-contact recreation is defined in the guideline *"as an activity where a person would have very limited direct contact with the water, usually only the feet and hands, and little risk of complete immersion. Some examples of activities include boating, fishing, flat water kayaking, canoeing and rafting, etc."* (BC Ministry of Environment. 2001). Secondary contact includes the recreational harvest of crustaceans (crabs, shrimp, prawns, barnacles, etc.).

Primary-contact recreation is defined as "*an activity where a person would have direct contact with water over most of the body's surface, to the point of complete submergence, or where there is substantial risk of ingestion or intimate contact with eyes, ears, nose, mouth or groin.*

Some examples of activities include swimming, diving, wading, SCUBA, and water sports where dunking is commonly expected such as white water canoeing, kayaking and rafting, board and windsurfing, water skiing, log birling, snorkeling, etc." (BC Ministry of Environment. 2001).

Bacteria, are non-conservative wastewater constituents because their levels decay over time. This is due to additional decay by predation, flocculation, sedimentation, and breakdown due to ultraviolet light.

Enterococci and *Escherichia Coli* decay rates in marine water are not well defined. *Enterococci* is the recommended indicator for sanitary contamination in marine recreational waters (Health Canada, 2012) partly due to its greater resistance to environmental stresses. The decay rate of *Enterococci* is assumed to be longer than that of fecal coliforms. Specific decay rates have not been adopted for *Enterococci and E.Coli.*

For the purpose of this study we have adopted Environment Canada's protocol for the determination if decay rates for fecal coliforms in the marine environment. Environment Canada adopted a standardized bacterial decay rate of $(K_b)_{20}$ = 9.2103 per day (T90 = 6hrs at 20°C). A conservative (i.e. minimum) temperature is used for each season and location to correct the decay rate, resulting in the corresponding T90 values:

Table 10 Proposed T90 Values – Fecal Coliform

Season	Summer	Winter
Temperature (˚C)	10	8
T90 (hrs.)	11.8	14.5

In addition to the BC water quality guidelines, Environment Canada requires that a 4-log reduction (i.e. 10,000:1 dilution) be achieved from raw sewage for the protection of human health against viruses (pers.com. Sarah Bartnik, 2013). The following dilution credits are given to treatment systems without disinfection:

- tertiary treatment systems are assigned a 3-log credit (1000:1),
- lagoon systems area assigned a 2-log (100:1);
- mechanical secondary systems receive a 1-log (10:1); and,
- reduction credit and primary treatment or raw discharges receive no reduction credit.

Environment Canada has adopted a conservative T90 of 500 hrs for the decay of viruses in the marine environment.

8.3 Microbiological Indicators and Virus Modelling Results

The predicted maximum allowable effluent concentrations of microbiological indicators based on the predicted dilution at 400 m, the most conservative water quality guideline and decay rates discussed in the previous section are provided in Table 11. The effective virus dilution (including decay) at 400 m is also provided in Table 11.

Table 11 Effective Dilution and Minimum Effluent Standards

Season		320 m^3/d			640 m^3/d			Minimum
Near Field Current (m/s)		**0.02**	**0.2**	**0.02**	**0.02**	**0.2**	**0.02**	
Far Field Current (m/s)		**0.02**	**0.2**	**0.2**	**0.02**	**0.2**	**0.2**	
Dilution @ 400 m	Summer	10,250	5,350	740	6,600	3,680	520	
	Winter	18,010	11,740	7,070	5,030	1,660	1,210	**520**
Effluent Enterococci (#/100 mL)	Summer	41,000	21,400	2,960	26,400	14,720	2,080	
	Winter	72,040	46,960	28,280	20,120	6,640	4,840	**2,080**
	Summer	143,500	74,900	10,360	92,400	51,520	7,280	

Effluent Escherichia Coli (# / 100 mL)	Winter	252,140	164,360	98,980	70,420	23,240	16,940	**7,280**
Effluent Fecal Coliform (#/100mL)	Summer	422,800	84,000	11,200	271,600	57,400	7,000	
	Winter	609,000	396,200	109,200	77,000	25,200	18,200	**7,000**
Available Virus Dilution (#:1)	Summer	10,519	5,369	751	6,777	3,696	528	
	Winter	18,485	12,048	7,095	5,049	1,673	1,223	**528**

Based on the results, disinfection of the effluent will be required to reduce effluent concentrations of microbiological indicators below minimum values provided in Table 11. The effective virus dilution is predicted to be a minimum of 528:1. Assuming a mechanical plant (without disinfection) a 1 log reduction (10:1) is achieved prior to discharge resulting in a total of 5,300:1. This is less than the minimum 10,000:1 required by Environment Canada. Disinfection of the effluent is therefore required to reduce effluent virus concentrations. A minimum 2 log reduction (100:1) in virus concentrations will be required in the treatment system to achieve Environment Canada guidelines.

9 Recommendations

9.1 Reliability

Based on results of this study it is recommended that the proposed wastewater facility conform to Category I requirements as outlined in Section 34 of the MWR.

Category I wastewater facilities are defined as a facility that discharges to water for which a short term effluent degradation could cause permanent or unacceptable damage to the receiving environment, including discharges near shellfish waters.

A short term degradation of effluent quality, specifically if the disinfection system were to fail, would not cause permanent damage. Bacteria and virus will ultimately decay and dilute in the receiving. A short term degradation may however cause unacceptable damage in the form of a temporary health risk if the facility were not compliant with Category I. Potentially, shellfish could be exposed for short durations to elevated bacteria or virus concentrations and then be harvested and consumed.

Short term degradation of other parameters such as TSS, and BOD_5 are unlikely to result in permanent or unacceptable damage to the receiving environment due to the high level of dilution predicted within the initial dilution zone, good flushing due to tides, and the relatively small volume of effluent discharged.

9.2 Pre-discharge Receiving Environment Monitoring

Receiving environment monitoring is a requirement under the *Municipal Wastewater Regulation*. Section 19 of the MWR states the EIS must establish a monitoring plan for both pre- and post-discharge that include details on monitoring locations, sampling parameters and frequencies (i.e. a schedule) (BC, 2012). Section 20 requires the receiving environmental monitoring program to:

- *Provide at least one control sampling station outside the influence of the IDZ [S. 20(1)(a)]*
- *Obtain data to assess potential impacts of the discharge [S. 20(1)(b)i];*
- *Assess whether the discharge causes applicable water quality guidelines to be exceeded beyond the edge of the IDZ [S. 20(1)(b)ii]; and*
- *Document pre-discharge conditions [S. 20(1) (c)], especially during "the most critical period of the year" [S. 20(2)].*

The following provides recommendations for pre-discharge monitoring.

9.2.1 Monitoring Objective

Proposed monitoring program should include the following objectives;

1. Characterize baseline (pre-discharge) conditions, including seasonal variations in water quality.
2. Characterize receiving environment water quality near the proposed discharge zone and nearby sensitive receptors.
3. Characterize receiving environment conditions at a control station.
4. Compare water quality results with applicable water quality guidelines.
5. Based on the findings, adjust the post-discharge monitoring study design as needed. Include water stations located on the IDZ and at the terminus of the outfall.

The recommended monitoring parameters are outlined in Table 12. Microbiological indicators should be monitored at both the boundary of the IDZ and the boundary of shellfish harvesting areas. Water column profiles should be collected during sampling to confirm the data inputs for dilution modelling.

Table 12 Pre-discharge Monitoring Requirements

	Parameters	Frequency	Sampling
Water Column Profiles	• Dissolved Oxygen (mg/L) • Temperature (˚C) • pH • Salinity (ppt)	The sampling protocol should consist of 5 weekly samples in 30 days.	In-situ
Water Samples	• Fecal coliforms • *Enterococcus*		Laboratory Analysis

9.2.2 Timing and Frequency

Pre-discharge monitoring must be conducted prior (suggested to be at least 90 days) to commissioning of the wastewater system. A minimum of two seasons should be sampled to represent the seasonal variation in the receiving environment. It is recommended that monitoring should occur in the spring/summer with during the Fraser River freshet and the winter with minimum discharge from the Fraser River.

For each season it is recommended that samples be collected to both provide a statistically significant number of samples to appropriately compare to applicable water quality guidelines and to account for seasonal variations. For microbiological and ammonia samples this includes the collection of a minimum of 5 weekly samples within a 30-day period. This is required for the calculation of mean, geometric means and 90th percentile microbiological concentrations for comparison with applicable water quality guidelines.

Table 13 Receiving Environment Monitoring Station Locations

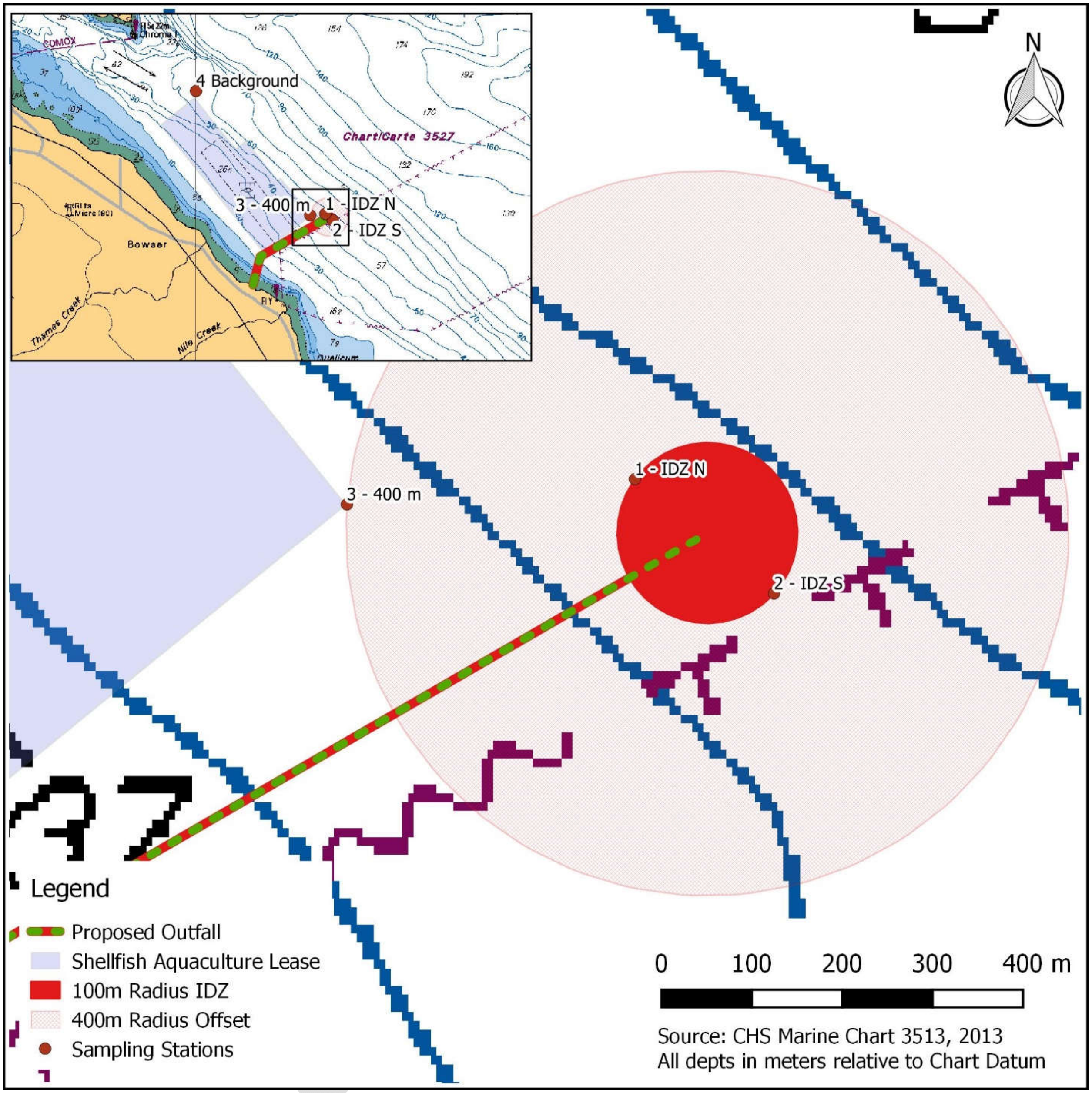


Table 14 Receiving Environment Monitoring Stations

Monitoring Stations	Description
S1	IDZ – north of terminus along dominant current direction
S2	IDZ – south of terminus along dominant current direction
S3	400m from terminus at boundary of shellfish aquaculture tenure
S4	Control Station

9.2.3 Sample Depths

It is recommended that samples be collected at a minimum of two depths. One sample should be collected at the approximate trapping depth of the effluent plume. The mid-point between the maximum and minimum trapping depths is recommended; 48 m in the summer and 43 m winter. A second sample should be collected mid water column (27 m), within the range of depths utilized by adjacent shellfish aquaculture operations.

10 Conclusion

Conclusions from this study include:

- The anticipated average dry weather flow at Bowser for the year 2030 is 320 m^3/day. A marine outfall to the open marine waters of the Strait of Georgia will provide a suitable and robust disposal method for the treated effluent.
- Site specific oceanographic characteristics ascertained from reference sources include:
  - The site is exposed to strong wind and associated large waves (significant wave heights over 1.8 m) from the south east.
  - Currents are primarily driven by tides. Maximum current speeds are anticipated to reach 0.2 m/s with dominant directions parallel to the shoreline.
  - Water density (temperature and salinity) will be mostly stratified in the spring/early summer during the Fraser River freshet. Winter conditions are anticipated to be the least stratified.
- The waters fronting Bowser and Qualicum Bay include important aquatic resources. These include:
  - Intertidal and subtidal bivalve shellfish that are harvested;
  - Herring spawning grounds; and,
  - Eelgrass beds.
- In order to meet the requirements of the MWR, the point of discharge will need to be a minimum of 400 m from shellfish waters. Options for outfall locations in proximity to Bowser occur on either side of the BC Hydro sub-marine right of way.
- Other potential receptors in the region include salmon, rockfish, and recreational waters, however receiving water quality guidelines for microbiological indicators for shellfish

waters is the most restrictive; therefore, shellfish are considered to be the governing resource/receptor for the proposed outfall.
- Dilution modelling of the effluent plume was completed for the proposed discharge. Modelling results predict a minimum dilution of 282:1 will be achieved at the boundary of the IDZ.
- Based on the effective dilution of microbiological indicators and viruses in the effluent plume, effluent fecal coliform concentrations should be less than 7,000 MPN/100 mL to achieve shellfish water quality guidelines at the boundary of shellfish harvesting waters.

11 Closure

If you have any questions or require further details, please contact the undersigned at any time.

Sincerely,

Jason Clarke, P. Eng.
Director

Peter Howland, B.Sc.
Director

12 References

British Columbia. 2012. Municipal Wastewater Regulation. B.C. Reg. 87/2012. Deposited April 20, 2012. Victoria, British Columbia.

British Columbia Marine Conservation Analysis (BCMCA). 2011. Rockfish Conservation Areas. Available online: http://bcmca.ca/datafeatures/hu_commercialfish_rcas/

British Columbia Marine Conservation Analysis (BCMCA). 2011. Scuba Dive Sites. Available online: http://bcmca.ca/datafeatures/hu_tourismrec_marinas/

British Columbia. 2015a. Conservation Lands. Fish, Wildlife and Habitat Management – Ministry of Forests, Lands and Natural Resources Operations. Available online: http://www.env.gov.bc.ca/fw/habitat/conservation-lands/

British Columbia. 2015b. Land Act [RSCS 1996] Chapter 245. Queen's Printer, Victoria, British Columbia, Canada. Available online: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_96245_01#

Canadian Food Inspection Agency. 2013. Canadian Shellfish Sanitation Program Manual of Operations. Version 4. Available online: http://www.inspection.gc.ca/DAM/DAM-food-aliments/STAGING/text-texte/fish_man_shellfish_def_1363877258513_eng.pdf

Environment Canada. 2002. Methods for Mapping and Monitoring Eelgrass Habitats in British Columbia. Available at: www.cmnbc.ca/sites/default/files/Methods%20for%20Mapping%20and%20Monitoring%20Eelgrass%20Habitat%20in%20British%20Columbia,%202002.pdf

Environment Canada. 2014a. 1981-2010 Climate Normals and Averages. Qualicum R Fish Research. Available online: http://climate.weather.gc.ca/climate_normals/index_e.html

Environment Canada. 2014b. 1981-2010 Climate Normals and Averages. Comox Airport. Available online: http://climate.weather.gc.ca/climate_normals/index_e.html

Environment Canada. 2015. Historical Climate Data - Sisters Island. Available online: http://climate.weather.gc.ca/index_e.html

Fisheries and Oceans Canada (DFO). 2008a. Canadian Tide and Current Tables. Volume 5. Juan de Fuca Strait and Strait of Georgia. Ottawa.

Fisheries and Oceans Canada (DFO). 2008b. Current Atlas – Juan de Fuca Strait to Strait of Georgia. Ottawa.

Fisheries and Oceans Canada (DFO). 2014. Sailing Directions – Juan de Fuca Strait to Strait of Georgia. Ottawa.

Gower, J., McLaren, R. 2000. Climatological Data from The Western Canadian ODAS Marine Buoy Network. Institute of Ocean Sciences and Environment Canada.

Health and Welfare Canada. 2012. Guidelines for Canadian Recreational Water Quality. Third Edition. Minister of Health.

Ministry of Environment, Land and Parks (MELP). 2000. Environment Impact Study Guideline – A Companion Document to the Municipal Sewage Regulation. Issued: December 2000.

Ministry of Environment (MOE). 2001. Water Quality Criteria for Nitrogen (Nitrate, Nitrite, and Ammonia). Available online: www.env.gov.bc.ca/wat/wq/BCguidelines/nitrogen/nitrogen.html

Ministry of Environment (MOE). 2015. Bowser Ecological Reserve. BC Parks. Available online: http://www.env.gov.bc.ca/bcparks/eco_reserve/bowser_er/bowser.pdf?v=1445017660025

Ministry of Environment (MOE). 2015. Authorization Database Search. Available online: http://www2.gov.bc.ca/gov/content/environment/waste-management/waste-discharge-authorization/managing-authorizations/authorization-database-search

Ministry of Forests, Lands and Natural Resource Operations (FLNRO). 2015. Parksville-Qualicum Beach Wildlife Management Area. Province of British Columbia.

Stantec. 2015. Bowser WWTP – Treatment technology options analysis. Technical memorandum prepared for the Regional District of Nanaimo.

Thompson, R.E. 1981. Oceanography of the British Columbia Coast. Department of Fisheries and Oceans. Ottawa.

US Army Corps of Engineers. 1984. Shore Protection Manual Volume II. Prepared for the Department of The Army, Washington DC.

Appendix C

Bowser Village Centre – Wastewater Service Preliminary Geotechnical Assessment, February 1, 2016

Bowser Village Centre – Pump Station Sites Geotechnical Assessments, August, 2016

Date: 1 February 2016
Project No.: 151-64145-00

Stantec
400 – 655 Tyee Road
Victoria, BC
V9A 6X5

Attention: Mr. Stan Spencer, M.A.Sc., P.Eng.
Principal

Project: Bowser Village Centre – Wastewater Service
Subject: Preliminary Geotechnical Assessment

Dear Mr. Spencer,

1.0 INTRODUCTION

As requested, WSP Canada Inc. (WSP – formerly Levelton Consultants) has completed a preliminary geotechnical assessment related to a new wastewater system for the Bowser Village Centre development being proposed by the Regional District of Nanaimo (RDN).

The purpose and scope of the review were presented in a proposal dated 14 May 2015 (Levelton file reference: P715-1173-00). Authorization to proceed with the work was received from Stantec on 28 July 2015 in the form of a Sub-Consultant Agreement. The proposed scope of work was based on the requirements outlined in the RDN's Request for Proposal entitled "*Detailed Design Services – Bowser Village Centre Wastewater Service: Collection, Treatment and Disposal,* dated 21 April 2015.

The following sections present a description of the proposed development, the results of a site reconnaissance and subsurface investigation, and provide preliminary geotechnical discussion and recommendations relating to the proposed wastewater treatment and disposal.

2.0 PROJECT DESCRIPTION

According to the RDN[1], Village Centres are intended to be the focus of housing, employment and service provision in unincorporated rural areas through the creation of denser development in designated centres. The proposed Bowser Village Centre will be a mixed-use development with varying densities of multi-unit

1 RDN – Bowser Village Plan – June 2010.

WSP Canada Inc.
1935 Bollinger Road
Nanaimo, BC
V9S 5W9

Tel: 250-753-1077
Fax: 250-753-1203
www.wspgroup.com

housing and commercial space that is intended to be pedestrian oriented and/or transit supportive. The Bowser Village Centre comprises two areas: a 51 ha, roughly triangular area that extends from the ocean shoreline to Sundry Road on the west; and a rectangular area (currently designated as "future use") that is approximately 41.5 ha in area and situated south of Crosley Road. The outlines of the proposed village centre areas are delineated on Figure 1.

Figure 1. Overview map of the proposed Bowser Village Centre area (source: RDN).

As part of the proposed community development, the RDN is planning to provide wastewater services to the Village Centre. The services would include collection, treatment, and disposal of effluent.

Chatwin Engineering Ltd. (Chatwin) of Nanaimo completed a feasibility study of the wastewater services in 2011[2]. The feasibility study addressed the following key items:

1. The system will include a wastewater treatment plant that is capable of producing either Class A or Class B effluent (depending on the disposal method). The proposed location of the treatment plant site (designated as Area 1 in the Chatwin report) is shown on Figure 2 below;

2. There are two general alternatives for effluent disposal – marine outfall or in-ground:

   Marine disposal would involve an approximately 2.5 km forcemain pipeline between the proposed treatment plant and the ocean shoreline at Crane Road near Nile Creek to the south. The pipe would continue another approximately 2 km to a submarine discharge point;

   In-ground disposal would involve an approximately 2.5 km forcemain pipeline to the southwest of the village site. The proposed in-ground disposal site – designated as Area 2 – was located near the Island Highway on the north side of McColl Road.

3. The collection system within the village boundaries also has two alternative – a gravity system with a lift station at the shoreline at Coburn Road and a low pressure system that includes a series of pumps.

The locations of the in-ground disposal area (Area 2), and the marine disposal outlet point near Nile Creek are shown on Figure 2 below.

The general intent of the preliminary geotechnical assessment was to obtain sufficient background information for the RDN and Stantec to be able to make a decision regarding the selection of the type of collection, treatment, and disposal system that would proceed to detailed design. The background information relating to the local geotechnical conditions was obtained through a desktop review, site reconnaissance, and subsurface investigation – the results of which are presented in the following sections.

The Chatwin report identified Area 2 as a potential site for in-ground disposal of suitably treated effluent from the treatment plant. The general location of Area 2 was accessible for vehicles via McColl Road and two internal logging trails. In our June 2015 proposal, WSP proposed that this area be investigated through excavation of test pits and large-scale percolation tests as a means to characterize the general suitability of the near-surface soils for infiltration.

2 Chatwin Engineering Ltd. – Bowser Sewage Feasibility Study – February 2011

Following an initial site reconnaissance in November 2015, WSP attempted to obtain permission to enter the Crown Lands for purposes of exploration from the BC Ministry of Forests, Lands and Natural Resource Operations through FrontCounter BC. At that point, it was indicated that the entire area lies within a Coastal Douglas Fir (CDF) Conservation Area and that any exploration or development was prohibited by statute. Following this discovery, it was confirmed by the RDN that Area 1 had been exempted from the protected area through a lease agreement with the Province but that Area 2 was effectively off limits.

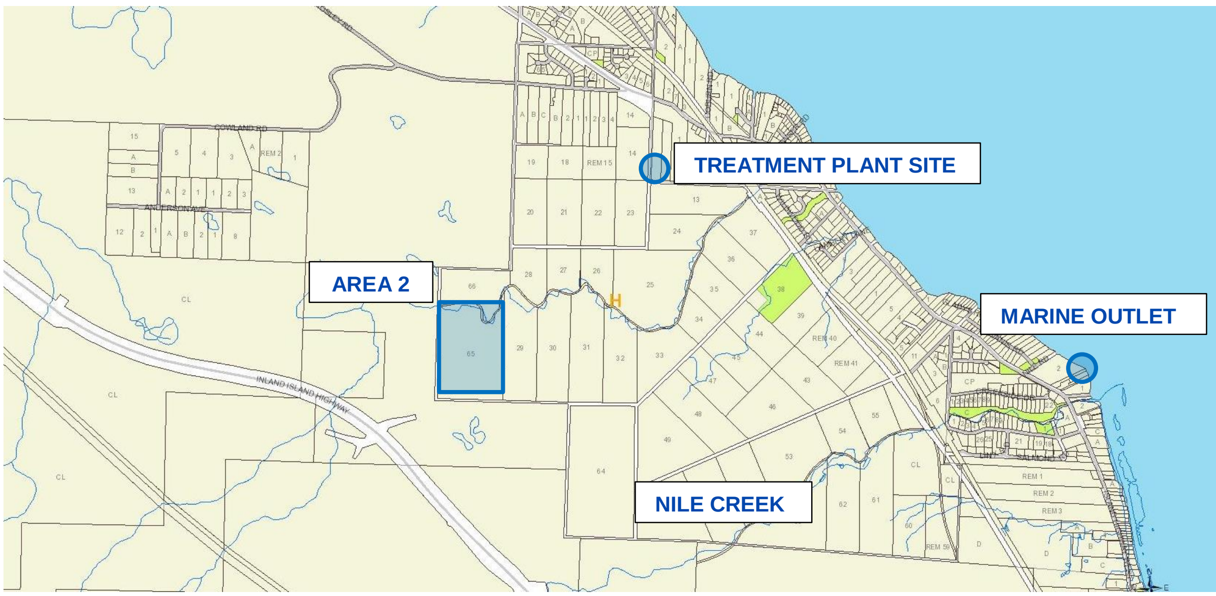


Figure 2. General area plan showing the location of the key items of the proposed wastewater system (after Chawin 2011).

Since that time, the RDN has suggested two alternative in-ground disposal sites. The first was to the south of the village near the BC Hydro transmission line right-of-way at Nile Creek. The second was to the west of the village, on the site of an existing seedling orchard. It is understood that these sites are outside of the CDF protection zone.

3.0 DESKTOP REVIEW

The desktop review primarily included aerial photographs, published surficial geology reports and mapping, published geology reports, RDN reports/mapping, and BC Ministry of Environment's waterwell atlas. The primary intent of the desktop review was to produce an overview of anticipated ground conditions within the proposed development area and to broadly define the potential geotechnical constraints or opportunities.

3.1 SURFICIAL GEOLOGY MAPPING

The surficial geology map for the local area[3] indicated that the general project area is underlain by a veneer of mixed marine sediments overlying glacial till. The veneer is mapped as being generally less than 1.5 m in thickness. In addition, the mapping indicates that the glacial till (Vashon Drift) is underlain at depth by Quadra Sediments. The upper sandy portion of the Quadra Sediments is used locally as a water supply aquifer.

The portion of the surficial geology map relevant to the project site is shown in Figure 3. The map indicates that the sequence of marine veneer and shallow till (12c/7) is prevalent throughout the Bowser Village area and is shown to underlie the treatment plant site, Area 2, and the alternative disposal sites. Inferred cross-sections from local river valleys (Thames and Nile Rivers) indicate that the thickness of the till ranges from about 5 to 15 m. The till is typically a very dense heavily over consolidated deposit with favourable bearing properties and very low hydraulic conductivity (permeability). It is often viewed as an aquitard to the underlying Quadra sediments.

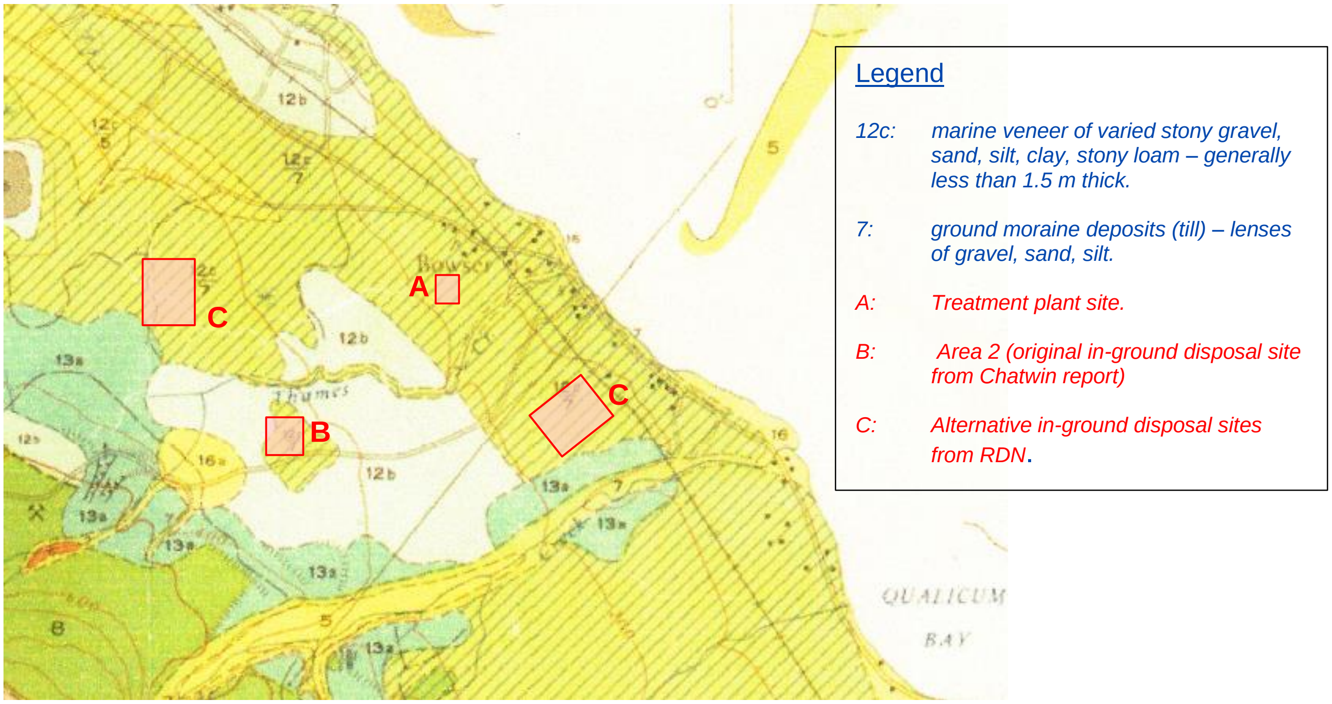


Figure 3. Surficial geology (GSC Map 1111A – 1962).

[3] GSC Surficial Geology Map 1111A – Horne Lake (1963).

The surficial geology mapping indicates that the ocean shoreline through the area is underlain by recent Salish Sediments (16) that consist of shore, deltaic and fluvial deposits of gravel, sand, clay, and peat. Depending on the type of collection system that is selected, these deposits may have to be investigated and assessed for support of a pump station or pumps.

3.2 Waterwell Logs

Well records of local water supply wells were obtained from the BC Ministry of Environment's water well atlas[4]. The well records present a summary of inferred lithology over depth that is logged and recorded by the drillers. Interpretation of the driller's log was carried out to determine the thickness of till that was encountered during the well installation.

There were no water wells located within the designated project areas. Records reviewed for wells located to the east of the site and within the area of surficial geology mapping described above indicated till thickness of between 50 and 57 m. The records indicated the depth to the surface of the till ranged from about 0.6 to 4 m.

The wells in the area were typically extended to depths between 40 and 70 m – with the deeper wells being in the area to the southeast of the village. The driller's records showed the wells being terminated in 'sand' below the till, which is interpreted as being the upper part of the Quadra Sediments.

3.3 Aerial Photographs

The aerial photographs (air photos) reviewed were from Google Earth and indicated the majority of the project area to be covered with a thick forest cover. The two primary water courses in the area are Thames Creek to the north and Nile Creek to the south. There are no apparent abrupt changes in topographic elevation over the project area.

Comparing the air photo imagery dated 2005 to the current conditions indicated that little development has occurred in the project area over the past ten years. The seedling orchard that has been suggested as a disposal site to the west of the village is shown on the 2005 photos.

[4] http://maps.gov.bc.ca/ess/sv/wrbc/

4.0 FIELD WORK

4.1 GENERAL

The initially proposed field work described in WSP's May 2015 proposal consisted of a site reconnaissance and subsurface assessment that was focused primarily on the potential infiltration characteristics within Area 2. A reconnaissance was made of Area 2 prior to discovering that it was off limits to development. The following sections address the proposed treatment plant site and the alternative disposal sites suggested by the RDN

4.2 TREATMENT PLANT SITE

As described above, the proposed treatment plant site was designated as Area 1 in the Chatwin report. The approximate location of the site is indicated in Figures 2 and 3 above. The following describes the results of a site reconnaissance and limited subsurface investigation program carried out by WSP in November/December 2015.

In general, this area was forested with relatively thick undergrowth. The ground surface was generally level with a gentle slope down to the north and northeast. There was no practical vehicle access to the designated treatment plant site.

The property to the east had been cleared of tree and undergrowth. There was a well-established ditchline that collected and directed flows from the west (i.e. forested area) around the cleared land. Near the southwest corner of the property, the ditch was about 1.2 m in depth and 1.5 m in width. The soils exposed within the ditch side walls at this location consisted of generally loose, clean, well-graded sand and gravel with cobbles overlying stiff/hard, sandy silt with gravel, which was interpreted to be glacial till. The thickness of the sand and gravel was about 0.6 m in this area.

On 21 December 2015, WSP mobilized a crew of workers to the proposed treatment plant site to carry out a series of three WildCat Penetrometer tests. The WildCat Penetrometer test (WPT) involves hand-held equipment that drops a standard weight of hammer a specific distance onto a series of rods that drive a cone into the ground. The number of blows to drive the cone and rods a specified distance (10 cm) are recorded and correlated to empirical values of soil consistency.

Two WPT's were located in the area of the treatment plant at the southwest corner of the property. These tests (WPT15-01 and WPT15-02) were extended to depths of 1.1 m – where effective penetration refusal was met with blow counts of over 50 per 10 cm. This correlates to a dense/very dense or hard consistency, which was interpreted to correspond to the silt till observed within the ditchline on the neighbouring property.

The third test (WPT15-03) was located near the north end of the property. The test was advanced to about 0.7 m before meeting effective refusal with a blow count of 75 per 10 cm. Again, this was interpreted to represent the surface of the silt till.

Figure 4. Area 1 showing approximate location of the WildCat Penetrometer holes.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 GENERAL

The primary intent of the current geotechnical assessment was to complete a desktop study of available information relating to the general subsurface ground conditions in the local area in relation to the potential suitability for in-ground disposal of treated waste water. The results of the information review were to be used by the RDN and Stantec as part of the decision making process in determining whether to proceed with the development of an in-ground system or to focus efforts towards an alternative marine disposal system.

5.2 GROUND DISPOSAL SITE

The information review indicated that the project area is generally underlain by a veneer of marine deposits overlying shallow glacial till that extends several tens of metres below ground surface prior to contacting the Quadra Sediments. In general, glacial till tends to be relatively impermeable, is not conducive to infiltration of surface water, and is not considered suitable for development of in-ground disposal fields.

Local evidence of this condition was indicated from a field visit by the RDN to the second alternative disposal site near the powerline right-of-way where areas of ponded or standing water were observed and substantial runoff or overland flow was occurring after rainfall. Both of these phenomena indicate that there was very little infiltration of the rain fall likely due to the restricting presence of the glacial till.

As shown in Figure 3 above, the marine veneer/glacial till condition is prevalent over the majority of the local area. It is also shown to underlie the seedling orchard area to the west. Given the required capacity of the proposed system indicated by Stantec, it does not appear that the local surficial geology would be suitable for development of an in-ground system. As such, from a geotechnical perspective, marine disposal should be considered as an alternative.

5.2 TREATMENT PLANT

Interpretation of the results of the background review, field reconnaissance, and the subsurface probing with the WCT has indicated that the proposed treatment plant site is underlain by shallow, competent, glacial till soil that would be expected to provide suitable bearing support for the treatment plant building and associated equipment.

The WCP – and observations of local soil exposures – indicated that the consistency of the silt till was ‘very dense’ or ‘hard’. For the purposes of preliminary foundation design, an allowable bearing capacity for footings sitting directly on a subgrade of undisturbed till would be in the order of 250 kPa.

The review of local waterwell logs indicated that descriptions of “till” soils extended to depths of more than 50 m. Under this condition, the treatment site could be considered as a seismic Site Class ‘C’ according to the 2012 BC Building Code.

Under the interpreted conditions, general site preparation for the treatment plant site would involve clearing of vegetation and stripping of surficial topsoil and the veneer of sand and gravel to expose an undisturbed subgrade of intact till. If necessary, design grades could be raised through the placement of engineered fill bearing on an approved subgrade of till

The mapping indicates that the shallow till extends essentially to the shoreline through the project area and, as such, would likely form the subgrade for the collection and conveyance system. Note, however, that structures at the shoreline could be underlain by the Salish Sediments atop the till and could be subject to adverse geotechnical constraints such as bearing capacity and poor seismic response. Once the configuration of this part of the system has been confirmed, these area should be subject to site specific subsurface investigation for input to detailed design.

6.0 CLOSURE

This overview report has been prepared by WSP Canada Inc. for Stantec in accordance with the attached Terms of Reference for Geotechnical Reports and the Sub-Consultant Agreement of July 2015. The RDN is considered to be an approved user of this report, subject to the conditions of the contract with Stantec.

We trust that the information presented above meets your current requirements. If you have any questions, or require further information, please to not hesitate to contact the undersigned.

Yours truly,
WSP Canada Inc.

Reviewed by :

Signature on File

Per: Tom Oxland, P.Eng.
Senior Geotechnical Engineer

Carl Miller, M.Sc., P.Eng.
Manager, VI Geotechnical

Attachments: Terms of Reference for Geotechnical Reports

TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS ISSUED BY WSP CANADA INC.

1. STANDARD OF CARE

WSP Canada Inc. ("WSP") prepared and issued this geotechnical report (the "Report") for its client (the "Client") in accordance with generally-accepted engineering consulting practices for the geotechnical discipline. No other warranty, expressed or implied, is made. Unless specifically stated in the Report, the Report does not address environmental issues.

The terms of reference for geotechnical reports issued by WSP (the "Terms of Reference") contained in the present document provide additional information and caution related to standard of care and the use of the Report. The Client should read and familiarize itself with these Terms of Reference.

2. COMPLETENESS OF THE REPORT

All documents, records, drawings, correspondence, data, files and deliverables, whether hard copy, electronic or otherwise, generated as part of the services for the Client are inherent components of the Report and, collectively, form the instruments of professional services (the "Instruments of Professional Services"). The Report is of a summary nature and is not intended to stand alone without reference to the instructions given to WSP by the Client, the communications between WSP and the Client, and to any other reports, writings, proposals or documents prepared by WSP for the Client relative to the specific site described in the Report, all of which constitute the Report.

TO PROPERLY UNDERSTAND THE INFORMATION, OBSERVATIONS, FINDINGS, SUGGESTIONS, RECOMMENDATIONS AND OPINIONS CONTAINED IN THE REPORT, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WSP CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT AND ITS VARIOUS COMPONENTS.

3. BASIS OF THE REPORT

WSP prepared the Report for the Client for the specific site, development, building, design or building assessment objectives and purpose that the Client described to WSP. The applicability and reliability of any of the information, observations, findings, suggestions, recommendations and opinions contained in the Report are only valid to the extent that there was no material alteration to or variation from any of the said descriptions provided by the Client to WSP unless the Client specifically requested WSP to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information, observations, findings, suggestions, recommendations and opinions contained in the Report, or any component forming the Report, are for the sole use and benefit of the Client and the team of consultants selected by the Client for the specific project that the Report was provided. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION OR COMPONENT WITHOUT THE WRITTEN CONSENT OF WSP. WSP will consent to any reasonable request by the Client to approve the use of this Report by other parties designated by the Client as the "Approved Users". As a condition for the consent of WSP to approve the use of the Report by an Approved User, the Client must provide a copy of these Terms of Reference to that Approved User and the Client must obtain written confirmation from that Approved User that the Approved User will comply with these Terms of Reference, such written confirmation to be provided separately by each Approved User prior to beginning use of the Report. The Client will provide WSP with a copy of the written confirmation from an Approved User when it becomes available to the Client, and in any case, within two weeks of the Client receiving such written confirmation.

The Report and all its components remain the copyright property of WSP and WSP authorises only the Client and the Approved Users to make copies of the Report, but only in such quantities as are reasonably necessary for the use of the Report by the Client and the Approved Users. The Client and the Approved Users may not give, lend, sell or otherwise disseminate or make the Report, or any portion thereof, available to any party without the written permission of WSP. Any use which a third party makes of the Report, or any portion of the Report, is the sole responsibility of such third parties. WSP accepts no responsibility for damages suffered by any third party resulting from the use of the Report. The Client and the Approved Users acknowledge and agree to indemnify and hold harmless WSP, its officers, directors, employees, agents, representatives or sub-consultants, or any or all of them, against any claim of any nature whatsoever brought against WSP by any third parties, whether in contract or in tort, arising or related to the use of contents of the Report.

TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS
ISSUED BY WSP CANADA INC. (continued)

5. INTERPRETATION OF THE REPORT

a. Nature and Exactness of Descriptions: The classification and identification of soils, rocks and geological units, as well as engineering assessments and estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1 above. The classification and identification of these items are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations or assessments utilizing the standards of Paragraph 1 involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to changes over time and the parties making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or when the Client has special considerations or requirements, the Client must disclose them to WSP so that additional or special investigations may be undertaken, which would not otherwise be within the scope of investigations made by WSP or the purposes of the Report.

b. Reliance on information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site investigation and field review and on the basis of information provided to WSP. WSP has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, WSP cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the report as a result of misstatements, omissions, misrepresentations or fraudulent acts of persons providing information.

c. Additional Involvement by WSP: To avoid misunderstandings, WSP should be retained to assist other professionals to explain relevant engineering findings and to review the geotechnical aspects of the plans, drawings and specifications of other professionals relative to the engineering issues pertaining to the geotechnical consulting services provided by WSP. To ensure compliance and consistency with the applicable building codes, legislation, regulations, guidelines and generally-accepted practices, WSP should also be retained to provide field review services during the performance of any related work. Where applicable, it is understood that such field review services must meet or exceed the minimum necessary requirements to ascertain that the work being carried out is in general conformity with the recommendations made by WSP. Any reduction from the level of services recommended by WSP will result in WSP providing qualified opinions regarding adequacy of the work.

6. ALTERNATE REPORT FORMAT

When WSP submits both electronic and hard copy versions of the Instruments of Professional Services, the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding upon WSP. The hard copy versions submitted by WSP shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancy, the hard copy versions shall govern over the electronic versions; furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed and sealed versions of the Instruments of Professional Services maintained or retained, or both, by WSP shall be deemed to be the overall originals for the Project.

The Client agrees that the electronic file and hard copy versions of Instruments of Professional Services shall not, under any circumstances, no matter who owns or uses them, be altered by any party except WSP. The Client warrants that the Instruments of Professional Services will be used only and exactly as submitted by WSP.

The Client recognizes and agrees that WSP prepared and submitted electronic files using specific software or hardware systems, or both. WSP makes no representation about the compatibility of these files with the current or future software and hardware systems of the Client, the Approved Users or any other party. The Client further agrees that WSP is under no obligation, unless otherwise expressly specified, to provide the Client, the Approved Users and any other party, or any or all of them, with specific software and hardware systems that are compatible with any electronic submitted by WSP. The Client further agrees that should the Client, an Approved User or a third party require WSP to provide specific software or hardware systems, or both, compatible with the electronic files prepared and submitted by WSP, for any reason whatsoever included but not restricted to an order from a court, then the Client will pay WSP for all reasonable costs related to the provision of the specific software or hardware systems, or both. The Client further agrees to indemnify and hold harmless WSP, its officers, directors, employees, agents, representative or sub-consultant, or any or all of them, against any claim or any nature whatsoever brought against WSP, whether in contract or in tort, arising or related to the provision or use or any specific software or hardware provided by WSP.

BOWSER VILLAGE CENTRE

PUMP STATION SITES GEOTECHNICAL ASSESSMENT

Stantec

Project No: 151-64145-00
Date: August 2016

WSP Canada Inc.
1935 Bollinger Road
Nanaimo, BC
V9S 5W9

Phone: 250-753-1077
Fax: 250-753-1203
www.wspgroup.com

WSP

Project No: 151-64145-00

Date: 10 August 2016

Stantec
400 – 655 Tyee Road
Victoria, BC
V9A 6X5

WSP Canada Inc.
1935 Bollinger Road
Nanaimo, BC
V9S 5W9

Tel: 250-753-1077
Fax: 250-753-1203

www.wspgroup.com

Attention: Mr. Stan Spencer, M.A.Sc., P.Eng.
Principal

Project: Bowser Village Centre – Wastewater Pump Station Sites

Subject: Geotechnical Assessment

Dear Mr. Spencer,

As requested, WSP Canada Inc. has carried out a geotechnical assessment in support of the preliminary design of the three pump stations associated with the Bowser Village Centre development proposed by the Regional District of Nanaimo. This work was supplemental to a preliminary geotechnical assessment that was completed buy WSP for the overall wastewater system in February 2016.

We trust that the information provided in the following geotechnical assessment report meets the anticipated requirements of this phase of the project. If you have any comments or questions, or require further information, please contact the undersigned.

Yours truly,
WSP Canada Inc.

Tom Oxland, P.Eng.
Senior Geotechnical Engineer

1 INTRODUCTION

As requested, WSP Canada Inc. (WSP) has carried out a geotechnical assessment in support of preliminary design for the three pump stations associated with the Bowser Village Centre wastewater treatment and disposal system being proposed by the Regional District of Nanaimo (RDN).

The purpose and scope of work for the geotechnical assessment were presented in a written proposal dated 24 February 2016 (WSP file reference: 151-64145-00). Authorization to proceed with the work was received from Stantec on 25 March 2016.

The general locations for the proposed pump stations were provided to WSP by Stantec on 19 May 2016. Detailed location plans for each site were received on 1 June 2016.

The following presents the results of a subsurface investigation program that was carried out on 7 June 2016 and provides geotechnical discussion and recommendations relating to the preliminary design of the pumps stations. Attached to this report are figures indicating the location and published geology at the pump station sites along with an appendix of borehole logs and test results,

2 SITE DESCRIPTION

The Bowser Village Centre proposed by the RDN includes a wastewater collection, treatment, and disposal system that will require a series of pump stations situated within the relatively low elevation area along the ocean shoreline to pump wastewater to the proposed treatment plant site on the west side of the Island Highway (19A).

The area of the proposed Bowser Village Centre that contains the pump station sites is roughly triangular and extends from the ocean shoreline on the east to Sundry Road on the west. The pump station sites are situated in public right-of-way's within areas that are currently developed with single family residences.

The pump station sites are located as follows:

Pump Station #1 Bowser Road	near the toe of the former shoreline slope at Garrod Avenue (7 m elev.)
Pump Station #2 Midland Road	northern extent of public road (14 m elev.)
Pump Station #3 Thompson Clarke Road	south of the intersection with Maple Guard Drive (24 m elev.)

The approximate pump station site locations are shown on the Site Location Plan attached as Figure 1.

3 SUBSURFACE ASSESSMENT

A subsurface assessment that consisted of advancing a single borehole at each pump station site was carried out on 7 June 2016. The boreholes were advanced using a track-mounted auger drill rig operated by Blue Max Drilling from Courtenay. The boreholes were advanced to between depths of 3.5 and 7 m and to effective refusal within dense deposits.

Prior to drilling, WSP visited the sites with a private utility locates contractor (Kelly's 1st Call) from Nanaimo. The pump station site locations were located from the site plans provided by Stantec and the borehole locations were cleared from conflict with underground services and marked in the field with survey paint.

The boreholes were advanced using a hollow-stem auger and Standard Penetration Tests (SPT's) were carried out at approximately 1.5 m intervals. The samples obtained were returned to the WSP laboratory in Nanaimo for detailed visual identification and moisture content determination.

A standpipe piezometer was installed in Borehole BH16-01 – located adjacent to Bowser Road. This was the only borehole that encountered significant groundwater seepage.

None of the boreholes were located in areas of pavement. Following drilling, the boreholes were backfilled with the drill cuttings to ground surface.

4 SUBSURFACE CONDITIONS

The results of a background information review of available published mapping indicated that, in general, the area of the proposed village centre that contains the pump station sites is underlain by a veneer of granular marine deposits overlying glacial till soils. The ocean shoreline along the east edge of the proposed village area is underlain by recent marine intertidal and/or beach marine deposits that in turn rest on the older glacial till soils. Figure 2 indicates the local surficial geology in relation to the pump station sites.

As indicated above, Borehole BH16-01 was situated at a relatively low elevation and adjacent to the toe of the former shoreline slope at the eastern extent of Bowser Road. This borehole encountered approximately 6 m of fine or medium grained sand with varying amounts of silt and gravel. Between about 3 and 5 m depth, the SPT blow count data indicated that the sand was indicative of a 'very loose' to 'loose' consistency. After drilling (17 June), the groundwater table was measured at 4.6 m depth in this deposit. At 6.1 m depth, the sands were underlain by dense, well-graded, silty sand with gravel that was interpreted to be glacial till.

The remaining boreholes (BH16-02 and BH16-03) were located further inland and at relatively higher elevations. In these boreholes, the interpreted surface of the glacial till was within 2 m of the ground surface. Borehole BH16-03 was terminated due to effective auger penetration refusal at 3.5 m depth. Neither of these boreholes encountered significant groundwater seepage.

Descriptions of the soil conditions encountered in the boreholes, along with the results of the laboratory testing, are summarized in the appended Borehole Summary Logs.

5 DISCUSSION AND RECOMMENDATIONS

Based on the results of the subsurface assessment, the soil conditions encountered at the proposed pump station sites are generally consistent with those anticipated by the preliminary background information review and published surficial geology mapping. Each of the sites is underlain by natural dense glacial till soils at relatively shallow depths. The exception is Pump Station #1 – where the surface of the glacial till at the borehole location was about 6 m below ground surface.

5.1 PUMP STATION SITE NO. 1

The borehole in the proposed vicinity of the Pump Station No. 1 site was located on the east side of Bowser Road immediately across from its intersection with Garrod Road. The borehole was situated near the toe of the shoreline slope and slightly higher in elevation than the beach to the north. The shoreline slope in this area sloped up toward Park Avenue and the Island Highway to the south.

The borehole at this location (BH16-01) encountered about 6 m of varying, interlayered sand/silty sand overlying very dense silty sand (till). Observations made during drilling and a piezometer reading made ten days after drilling indicated that these sands were saturated below about 4.5 m depth. It is possible that a greater portion of the sands become saturated in the winter months when the watertable is expected to be higher.

The assessment is in support of preliminary design and structural details of the pump station at this location were not known to WSP at the time of preparation of this report. However, previous experience with similar installations have involved excavations of between 4 and 6 m depth to found the wet well.

Based on the soil conditions encountered in the borehole, there are a number of geotechnical concerns or constraints associated with the currently proposed Pump Station No. 1 site. These include:

- Structural loads from the pump station should be extended to bear on the glacial till surface at about 6 m below ground surface or potentially at a higher elevation on an engineered fill that bears on the glacial till. Depending on the depth of the proposed station, this could involve bulk excavation (see below) to expose the till. The installation of piers or piles through the upper sands to the till deposit could be an alternative approach provided that the foundation design can accommodate the seismic aspects of soil/structure interaction is an earthquake design event (see below).
- The pump station will need to be designed to resist hydrostatic uplift or buoyancy. The magnitude of forces will depend on the configuration of the structure relative to the watertable and will need to be reviewed during final design;
- The majority of the temporary excavation for construction of the pump station will take place in the loose, potentially saturated sands overlying the sand till. Given the location of adjacent private property and Bowser Road, it is unlikely that the excavation sidewalls could be graded back to a stable configuration for construction. As such, these conditions will require mechanical support in the form of shoring.

The temporary works will need to address construction excavation dewatering. The extent and methodology for excavation dewatering will depend on the system of shoring and the duration of the works. An important consideration in the long term foundation design will be protect the bearing surface from excessive heave and damage due to hydrostatic uplift. From a construction perspective, the contractor's methodology will need to address disposal of collected water and the mitigation of harm to the nearby aquatic environment.

- The saturated loose sands below and adjacent to the pump station would be susceptible to liquefaction in response to the local design earthquake. This could results in loss of vertical bearing capacity for the pump station foundation as well as impart relatively substantial lateral loads on the pump station walls as the liquefied soils displace laterally towards the ocean. Related to this issue is the performance of buried piping entering the pump station, which would be expected to strain as a result of the permanent ground deformation.

The presence of potentially liquefiable soils at this site would render it a seismic Site Class "F" according to the 2012 BC Building Code. As a result, addressing (through mitigation) or incorporating the potential impact of these soils would be required for final design.

One possible practical approach to mitigation would be to relocate the pump station further to the south towards the area of higher ground. Based on the anticipated local soil conditions, it is expected that as the ground surface elevation increases toward the south (i.e. toward Park Avenue), the thickness of the saturated marine deposits will decrease and the surface of the glacial till will become closer to the ground surface. As such, relocating the pump station further to the south could be explored as an option to effectively reduce the geotechnical issues outlined above. Based on local experience, for a site where shallow glacial till is present, it would be considered to be a Site Class of "C". If the pump station cannot be relocated to better ground, the following further exploration and testing work would be recommended prior to final design.

A test pit should be excavated at the pump station location to create a trial exposure of the potential subsurface conditions and ground response that would be encountered during construction. Such a test pit would allow for an estimate of potential inflow rates of groundwater as well as an assessment of the side slope stability (i.e. susceptibility to sloughing, base heave, etc). This would be somewhat disruptive to the ground surface and restoration should allow for some additional landscaping.

Based on the test pit and existing borehole information, geotechnical parameters could be developed for input to the excavation design. These would include estimated inflow rates and volumes to assist a qualified dewatering contractor to develop a temporary dewatering system. Given the anticipated conditions, it is considered that a sump and pump system within the excavation would not be effective due to the potential influence on groundwater on the stability of the side slopes. An effective dewatering system such as well points or larger diameter wells would have to lower the local groundwater table to below the depth of installation for a specific distance beyond the outside of the excavation perimeter prior to excavation.

Final design will be influenced by the geometry of the pump station relative to the presence (top) of the dense till. While the relocation concept discussed above would greatly mitigate many of the foundation items discussed above, a detailed review will be required to assess lateral loads on the pump station, possible requirements for ground improvement (excavate and replace or in situ) beyond and below the footprint of the station, and the associated implications to ground conditions to buried piping as well as necessary temporary works.

5.2 PUMP STATION SITES NO. 2 AND 3

Pump Stations No. 2 and 3 were located further inland – and upslope – compared to Pump Station No. 1 (Figure 2). The boreholes at these locations encountered dense to very dense, natural silty sand (till) at about 1.8 m in Borehole BH16-02 and less than 0.6 m in BH16-03. No significant groundwater seepage was encountered in either of the boreholes.

For these sites, foundation design and construction considerations are relatively straight forward. Temporary excavations could be extended to the surface of the glacial till which would provide adequate bearing for the pump station foundations. At both sites, it is expected that there is adequate lateral space to accommodate graded side slopes above the glacial till. Based on the borehole information, it is expected that temporary excavations in the glacial till could be cut near vertically, subject to field verification.

Due to the presence of relatively shallow, competent glacial till at both of these locations, these sites would be considered as seismic Site Class "C" according to the 2012 BC Building Code.

Typical values of factored settlement serviceability bearing capacities for footings bearing on an approved subgrade of glacial till – as encountered in the boreholes – would range from about 175 to 200 kPa. Potential total and differential settlements under these conditions would be in the order of 25 mm and 19 mm, respectively. Critical to the bearing surface is the need for protection of approved surfaces against traffic disturbance and excessive moisture change.

The glacial till encountered in BH16-03 (Pump Station #3) was within 0.6 m of ground surface and very dense (according to the SPT blow count data). While this can be favourable in relation to foundation bearing, the very dense soil can present a challenge to effective excavation for the service trench lines and/or the pump station. Relatively large, tracker excavation equipment will likely be required to adequately or practically excavate the till soils in this area.

The glacial till contains fine grained particles and the contractor will need to develop an erosion and sediment control plan for water discharge from the sites.

6 FUTURE GEOTECHNICAL WORK

Further geotechnical input will be required as the pump stations move into detailed design. The extent of input will be influenced by the relocation option for Pump Station 1 described above. Future elements of work are anticipated to include:

- Review of proposed pump station design in relation to the results of the geotechnical assessment – especially with regard to depth of installation for Pump Station #1;
- Further testing of potential seepage and excavation sidewall conditions through advancement of a test pits at the Pump Station #1 site;
- Defining till surface in the vicinity of Pump Station 1 to assist in the relocation option; and
- Input to, or review of, excavation and dewatering plans for the pump station sites – especially Pump Station #1.

WSP would be pleased to discuss the requirements for future geotechnical work as the project progresses.

7 CLOSURE

This geotechnical assessment for the proposed pump station sites for the RDN's Bowser Village Centre was carried out in accordance with the terms and conditions of WSP's July 2105 Subconsultant Agreement with Stantec for this project. The Regional District of Nanaimo is considered to be an authorized user of the report subject to the terms of engagement under which the work was completed. The report has been prepared in accordance with the appended Terms of Reference for Geotechnical Reports.

We trust that the information presented above meets your current requirements. If you have any questions, or require further information, please contact the undersigned.

Yours truly,
WSP Canada Inc.

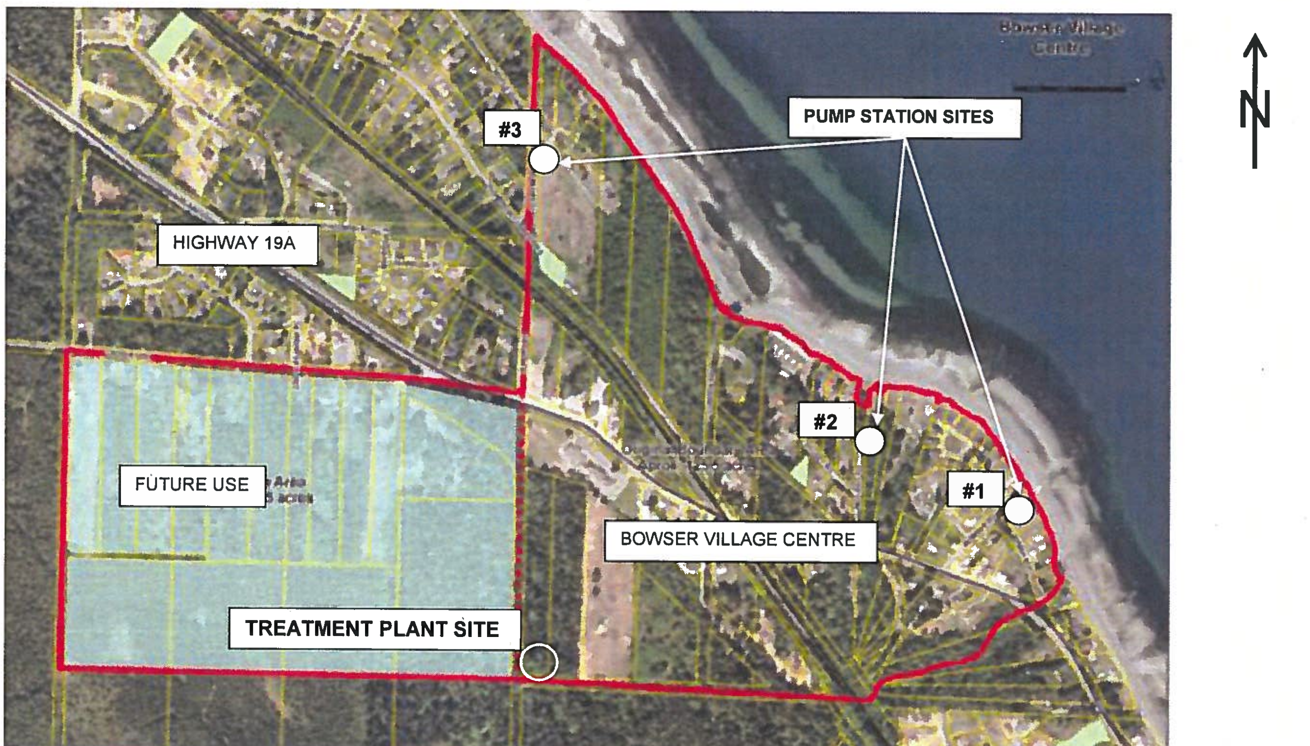
Review by:

Signatures on File

Per: Tom Oxland, P.Eng.
Senior Geotechnical Engineer

Carl Miller, P.Eng.
Senior Geotechnical Engineer

Attachments: Figure 1 – Site Location Plan
Figure 2 – Surficial Geology
Appendix 1. Borehole Summary Logs
Appendix 2. Terms of Reference for Geotechnical Reports



Based plan from Chatwin Engineering *Sewage Feasibility Study (2011).*

WSP	PROJECT: BOWSER VILLAGE CENTRE		
	TITLE: SITE LOCATION PLAN – PUMP STATION SITES		
	CLIENT: STANTEC / REGIONAL DISTRICT OF NANAIMO		
FIGURE NO.: 1	DATE: AUGUST 2016	FILE NO.: 151-64145-00	SCALE: NTS

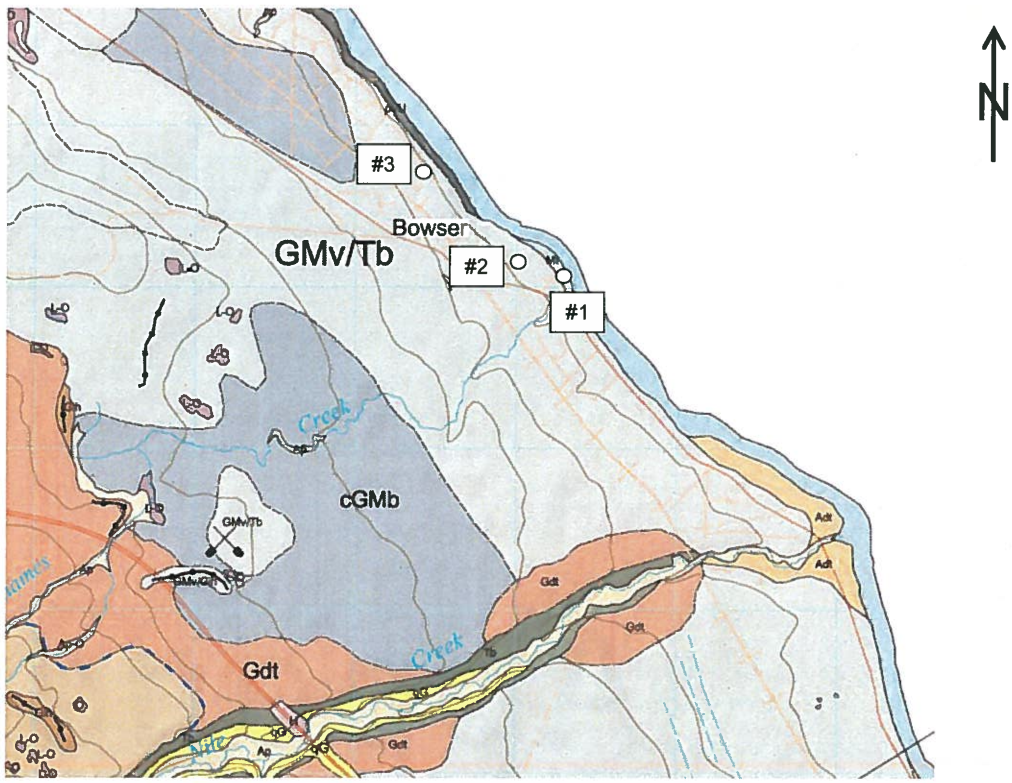
WSP Canada Inc., 1935 Bollinger Road, Nanaimo, B.C., V9S 5W9 Phone: 250-753-1077 Fax: 250-53-1203 Email: nanaimo@wspgroup.com

LEGEND

GMv/Tb = veneer of marine sediments overlying a blanket of glacial till.

Mt = marine sediments consisting of fine-grained intertidal and/or beach (sand) deposits.

GSC Open File 7681
Surficial Geology – Deep Bay to Nanoose Harbour



WSP	PROJECT: BOWSER VILLAGE CENTRE		
	TITLE: SURFICIAL GEOLOGY – PUMP STATION SITES		
	CLIENT: STANTEC / REGIONAL DISTRICT OF NANAIMO		
FIGURE NO.: 2	DATE: AUGUST 2016	FILE NO.: 151-64145-00	SCALE: NTS

WSP Canada Inc., 1935 Bollinger Road, Nanaimo, B.C., V9S 5W9 Phone: 250-753-1077 Fax: 250-753-1203 Email: nanaimo@wspgroup.com

Appendix I

BOREHOLE SUMMARY LOGS

WSP
WSP Canada Inc.
1935 Bollinger Road
Nanaimo, B.C. V9S 5W9
Tel: +1 250-753-1077
Fax: +1 250-753-1203
www.wspgroup.com

Bowser Village Centre
Pump Station Sites
Geotechnical Assessment

BH16-01

Project No: 151-64145-00

Depth (m)	Depth (ft)	Description	C	N	Type	Water Level	Moisture Content % (10–90)
0	0–0.5	ORGANIC TOPSOIL					
	0.5–8	dense, brown, medium grained, SAND, traces silt and gravel, moist, dense					
2	~6.2		Good	39	SPT		~5
	8–10.2	loose, dark brown, fine grained, silty SAND, some gravel, moist					
	~10		Disturbed		G		~27
	10.2–16.2	loose, brown, fine grained SAND, trace silt, wet					
	~11		Good	5	SPT		~20
	~15.3		Good	3	SPT	Jun 17 2016	~40
	16.2–20.5	light grey, fine to medium grained SAND, trace silt, saturated					
	~16.5		Disturbed		G		~36
	20.5–23	dense, grey/brown, well grained SAND (TILL), silty, gravelly, wet					
	~21.5		Good	50	SPT		~11
7	23	Standpipe Piezometer Installed Bottom of hole at 7 metres.					

C: Condition of Sample
- Good
- Disturbed
- No Recovery

Type: Type of Sampler
- SPT : 2 in. standard
- ST : Shelby
- FP : Fixed Piston
- G : Grab
- CORE

N: Number of Blows
- WH : Weight of Hammer
- WR : Weight of Rod
- Standard Penetration Test : ASTM D1586
- Hammer Type:

Legend:
- ● Moisture Content %
- Plastic Limit %
- Liquid Limit %
- Ground Water Level
- Shear strength in kPa (Torvane or Penetrometer)
- Shear strength in kPa (Unconfined)
- Shear strength in kPa (field vane)
- Remolded strength in kPa
- Percent Passing # 200 sieve

Drill Method: Hollow Stem Auger
Date Drilled: 17/06/2016
By: TWO

WSP Canada Inc.
1935 Bollinger Road
Nanaimo, B.C. V9S 5W9
Tel: +1 250-753-1077
Fax: +1 250-753-1203
www.wspgroup.com

Bowser Village Centre Pump Station Sites Geotechnical Assessment

BH16-02

Project No: 151-64145-00

Depth (m)	Depth (ft)	Description	C	N	Type	Water Level
0	0	brown, well-graded SAND and GRAVEL (FILL), trace/some silt, moist				
		grey/brown, well-graded SAND, some gravel, trace silt, moist				
	6	brown, well-graded, silty SAND (TILL), some gravel, moist	Good	40	SPT	
			Good	27	SPT	
	15	dark grey, sandy SILT (TILL), some fine gravel, moist	Disturbed		G	
			Good	30	SPT	
6	20	Bottom of hole at 6 metres.	Disturbed		G	

Chart scale: 10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good
Disturbed
No Recovery

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
FP : Fixed Piston
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type:

● Moisture Content %
Plastic Limit %
Liquid Limit %
Ground Water Level
Shear strength in kPa (Torvane or Penetrometer)
Shear strength in kPa (Unconfined)
Shear strength in kPa (field vane)
Remolded strength in kPa
Percent Passing # 200 sieve

Drill Method: Hollow Stem Auger
Date Drilled: 17/06/2016
By: TWO

WSP Canada Inc.
1935 Bollinger Road
Nanaimo, B.C. V9S 5W9
Tel: +1 250-753-1077
Fax: +1 250-753-1203
www.wspgroup.com

Bowser Village Centre
Pump Station Sites
Geotechnical Assessment

BH16-03

Project No: 151-64145-00

Depth (m)	Depth (ft)	Description	C	N	Type	Water Level
0	0	well-graded, gravelly SAND (FILL), some silt, moist				
		dense, brown, well-graded, silty SAND (TILL), trace to some gravel, moist				
2		Grinding on auger below 2 m.	Good	46	SPT	
		Difficult drilling below 3.2 m.	Good	86	SPT	
3.5		Bottom of hole at 3.5 metres due to effective penetration refusal.				

Plot scale: 10 20 30 40 50 60 70 80 90

C: Condition of Sample
Good ▨
Disturbed ▥
No Recovery □

Type: Type of Sampler
SPT : 2 in. standard
ST : Shelby
FP : Fixed Piston
G : Grab
CORE

N: Number of Blows
WH : Weight of Hammer
WR : Weight of Rod
Standard Penetration Test : ASTM D1586
Hammer Type:

● Moisture Content %
► Plastic Limit %
◄ Liquid Limit %
▼ Ground Water Level
∞ Shear strength in kPa (Torvane or Penetrometer)
✕ Shear strength in kPa (Unconfined)
⊗ Shear strength in kPa (field vane)
⊠ Remolded strength in kPa
■ Percent Passing # 200 sieve

Drill Method: Hollow Stem Auger
Date Drilled: 17/06/2016
By: TWO

1 LOG PER PAGE 23/6/16

Appendix II

TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS

TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS ISSUED BY WSP CANADA INC.

1. STANDARD OF CARE

WSP Canada Inc. ("WSP") prepared and issued this geotechnical report (the "Report") for its client (the "Client") in accordance with generally-accepted engineering consulting practices for the geotechnical discipline. No other warranty, expressed or implied, is made. Unless specifically stated in the Report, the Report does not address environmental issues.

The terms of reference for geotechnical reports issued by WSP (the "Terms of Reference") contained in the present document provide additional information and caution related to standard of care and the use of the Report. The Client should read and familiarize itself with these Terms of Reference.

2. COMPLETENESS OF THE REPORT

All documents, records, drawings, correspondence, data, files and deliverables, whether hard copy, electronic or otherwise, generated as part of the services for the Client are inherent components of the Report and, collectively, form the instruments of professional services (the "Instruments of Professional Services"). The Report is of a summary nature and is not intended to stand alone without reference to the instructions given to WSP by the Client, the communications between WSP and the Client, and to any other reports, writings, proposals or documents prepared by WSP for the Client relative to the specific site described in the Report, all of which constitute the Report.

TO PROPERLY UNDERSTAND THE INFORMATION, OBSERVATIONS, FINDINGS, SUGGESTIONS, RECOMMENDATIONS AND OPINIONS CONTAINED IN THE REPORT, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WSP CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT AND ITS VARIOUS COMPONENTS.

3. BASIS OF THE REPORT

WSP prepared the Report for the Client for the specific site, development, building, design or building assessment objectives and purpose that the Client described to WSP. The applicability and reliability of any of the information, observations, findings, suggestions, recommendations and opinions contained in the Report are only valid to the extent that there was no material alteration to or variation from any of the said descriptions provided by the Client to WSP unless the Client specifically requested WSP to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information, observations, findings, suggestions, recommendations and opinions contained in the Report, or any component forming the Report, are for the sole use and benefit of the Client and the team of consultants selected by the Client for the specific project that the Report was provided. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION OR COMPONENT WITHOUT THE WRITTEN CONSENT OF WSP. WSP will consent to any reasonable request by the Client to approve the use of this Report by other parties designated by the Client as the "Approved Users". As a condition for the consent of WSP to approve the use of the Report by an Approved User, the Client must provide a copy of these Terms of Reference to that Approved User and the Client must obtain written confirmation from that Approved User that the Approved User will comply with these Terms of Reference, such written confirmation to be provided separately by each Approved User prior to beginning use of the Report. The Client will provide WSP with a copy of the written confirmation from an Approved User when it becomes available to the Client, and in any case, within two weeks of the Client receiving such written confirmation.

The Report and all its components remain the copyright property of WSP and WSP authorises only the Client and the Approved Users to make copies of the Report, but only in such quantities as are reasonably necessary for the use of the Report by the Client and the Approved Users. The Client and the Approved Users may not give, lend, sell or otherwise disseminate or make the Report, or any portion thereof, available to any party without the written permission of WSP. Any use which a third party makes of the Report, or any portion of the Report, is the sole responsibility of such third parties. WSP accepts no responsibility for damages suffered by any third party resulting from the use of the Report. The Client and the Approved Users acknowledge and agree to indemnify and hold harmless WSP, its officers, directors, employees, agents, representatives or sub-consultants, or any or all of them, against any claim of any nature whatsoever brought against WSP by any third parties, whether in contract or in tort, arising or related to the use of contents of the Report.

TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS ISSUED BY WSP CANADA INC. (continued)

5. INTERPRETATION OF THE REPORT

a. **Nature and Exactness of Descriptions**: The classification and identification of soils, rocks and geological units, as well as engineering assessments and estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1 above. The classification and identification of these items are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations or assessments utilizing the standards of Paragraph 1 involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to changes over time and the parties making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or when the Client has special considerations or requirements, the Client must disclose them to WSP so that additional or special investigations may be undertaken, which would not otherwise be within the scope of investigations made by WSP or the purposes of the Report.

b. **Reliance on information**: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site investigation and field review and on the basis of information provided to WSP. WSP has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, WSP cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the report as a result of misstatements, omissions, misrepresentations or fraudulent acts of persons providing information.

c. **Additional Involvement by WSP**: To avoid misunderstandings, WSP should be retained to assist other professionals to explain relevant engineering findings and to review the geotechnical aspects of the plans, drawings and specifications of other professionals relative to the engineering issues pertaining to the geotechnical consulting services provided by WSP. To ensure compliance and consistency with the applicable building codes, legislation, regulations, guidelines and generally-accepted practices, WSP should also be retained to provide field review services during the performance of any related work. Where applicable, it is understood that such field review services must meet or exceed the minimum necessary requirements to ascertain that the work being carried out is in general conformity with the recommendations made by WSP. Any reduction from the level of services recommended by WSP will result in WSP providing qualified opinions regarding adequacy of the work.

6. ALTERNATE REPORT FORMAT

When WSP submits both electronic and hard copy versions of the Instruments of Professional Services, the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding upon WSP. The hard copy versions submitted by WSP shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancy, the hard copy versions shall govern over the electronic versions; furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed and sealed versions of the Instruments of Professional Services maintained or retained, or both, by WSP shall be deemed to be the overall originals for the Project.

The Client agrees that the electronic file and hard copy versions of Instruments of Professional Services shall not, under any circumstances, no matter who owns or uses them, be altered by any party except WSP. The Client warrants that the Instruments of Professional Services will be used only and exactly as submitted by WSP.

The Client recognizes and agrees that WSP prepared and submitted electronic files using specific software or hardware systems, or both. WSP makes no representation about the compatibility of these files with the current or future software and hardware systems of the Client, the Approved Users or any other party. The Client further agrees that WSP is under no obligation, unless otherwise expressly specified, to provide the Client, the Approved Users and any other party, or any or all of them, with specific software and hardware systems that are compatible with any electronic submitted by WSP. The Client further agrees that should the Client, an Approved User or a third party require WSP to provide specific software or hardware systems, or both, compatible with the electronic files prepared and submitted by WSP, for any reason whatsoever included but not restricted to an order from a court, then the Client will pay WSP for all reasonable costs related to the provision of the specific software or hardware systems, or both. The Client further agrees to indemnify and hold harmless WSP, its officers, directors, employees, agents, representative or sub-consultant, or any or all of them, against any claim or any nature whatsoever brought against WSP, whether in contract or in tort, arising or related to the provision or use or any specific software or hardware provided by WSP.

Appendix D

Technical Memorandums

Technical Memorandum 1 – Bowser WWTP – Treatment Technology Options Analysis, October 23, 2015

Technical Memorandum 2 – Revision 2 – Bowers WWTP – Effluent Disposal Option Analysis, April 25, 2016

Technical Memorandum 3 – Revision 1 – Bowser WWTP – Environmental Studies and Permitting Considerations, March 10, 2016

Technical Memorandum 4 – Bowser Village Centre Wastewater System – Desktop Environmental Review, May 30, 2016

Technical Memo 1

To:	Regional District of Nanaimo Gerald St. Pierre, P.Eng.	From:	David Lycon, P.Eng. Stantec – Surrey Office
File:	111700522	Date:	October 23, 2015

Reference: Bowser WWTP – Treatment Technology Options Analysis

1. INTRODUCTION

1.1 BACKGROUND

As part of the development of the preliminary design for the Bowser Village Centre Wastewater Service Project, a review of wastewater treatment technology options must first be undertaken. This analysis will provide a recommendation for the main secondary treatment option, along with a review of the required ancillary processes necessary to allow the Village to meet the treatment objectives for this project.

Recent work which was reviewed in the preparation of this technical memorandum includes:

- Regional District of Nanaimo RFP - Engineering Services — Bowser Village Centre Wastewater Service: Collection, Treatment, and Disposal Project; and
- Feasibility Study for Area-H Bowser Community Sewer Servicing Study (Chatwin Engineering 2011).

1.2 OBJECTIVE

The objective of this technical memorandum is to evaluate recommended secondary treatment options and select a treatment option to be progressed to preliminary design. Stantec has reviewed the aforementioned documents in order to establish the treatment needs of the Village of Bowser in the short and long term. Feasibility work on the treatment options is presented with respect to technology descriptions and cost estimates. The selection of the secondary treatment process is structured to allow both economic and non-economic factors to be considered in the decision making process. Non-economic factors will encompass the following:

1. Expandability;
2. Energy use;
3. Footprint requirement;
4. Visual impact / aesthetics;
5. Ease of operation; and
6. Reliability.

2. DESIGN CRITERIA

2.1 REGULATORY REQUIREMENTS

The regulatory guidelines to be used as a basis for this project come from the British Columbia Environmental Management Act's Municipal Wastewater Regulations (MWR). This regulation sets the requirements for treatment plant effluent quality, depending upon on the nature of the discharge environment. Concurrent with the work being conducted for this technical memorandum is the work being done in support of Technical Memorandum 2 – Effluent Disposal Options Analysis (Outfall vs. Ground). Both of the proposed disposal options require a distinct effluent quality, and as such will have a bearing on the final treatment technology selected.

With regards to ground disposal, the BC MWR is very prescriptive in terms of the required effluent quality. This effluent quality is outlined in Table 1 below.

Table 1. Effluent Quality Requirement for Ground Discharge

Requirement	Class A	Class B
BOD_5 (mg/L)	≤ 10	≤ 10
TSS (mg/L)	≤ 10	≤ 10
Fecal Coliform (MPN/100 mL)	2.2 (median) and 14 (max)	≤ 400
Turbidity (NTU)	2 (average) and 5 (max)	N/A
Nitrogen (mg/L)	Nitrate-N ≤ 10 Total-N ≤ 20	N/A

The differentiation between Class A and Class B effluent relates to the proximity of the wastewater ground discharge to a drinking water source's zone of influence. If the discharge is within 300 meters of the drinking water source's zone of influent, the effluent must meet Class A requirements.

For a marine discharge, the BC MWR guidelines are noted in Table 2.

Table 2. Effluent Quality Requirement for Marine Discharge

Requirement	Shellfish Bearing Waters[1]	Marine Waters
BOD_5 (mg/L)	≤ 45	≤ 45
TSS (mg/L)	≤ 45	≤ 45
Fecal Coliform - at the edge of the initial dilution zone (MPN/100 mL)	14 (median) and 43 (no more than 10% exceeding this value)	N/A

A final set of effluent quality guidelines will also require consideration, regardless of the selected effluent disposal option. Table 3 below outlines the wastewater treatment effluent guidelines from the Federal Wastewater Systems Effluent Regulations (WSER) of the Fisheries Act (2012).

Table 3. Federal Wastewater System Effluent Regulations

Requirement	Limit
$cBOD_5$ (mg/L)	≤ 25[2]
TSS (mg/L)	≤ 25[2]
Un-ionized Ammonia (@15 °C) (mg/L)	≤ 1.25
Total Chlorine Residual (mg/L)	≤ 0.02

2.2 WASTEWATER CHARACTERIZATION

In the absence of wastewater characterization data for the existing Bowser Village site, certain assumptions will have to be made using good industry practice. Consideration was given to using data from the French Creek PCC as a basis of design. However, as French Creek receives septage and is possibly influenced by sea water intrusion, this may not accurately represent the conditions that will be encountered for Bowser.

2.2.1 Design Populations, Flows and Loads

The 2011 Chatwin Engineering report entitled, *Feasibility Study for Area-H Bowser Community Sewer Servicing Study,* contained a basis of design that utilized population projections, per capita flows, and certain flow peaking factors. This data, along with additional peaking factors developed for

[1] This refers to an area that is located 300 meters or less from the edge of the initial dilution zone.
[2] Quarterly arithmetic mean of monthly grab samples

this tech memo, is presented in Table 4. A similar exercise has been conducted for the plant loading, with results presented in Table 5.

Table 4. Design Basis Population and Flow Information

Parameter	Phase 1 Year 2020	Phase 2 Year 2030
Population	445	890
Average Dry Weather Flow (m^3/d)	160	320
Maximum Month Flow (m^3/d)	200	400
Maximum Day Flow (m^3/d)	320	640
Peak Hour Flow (L/s)	6.6	13.3

Notes:

(1) Average day flow= 360 L/c/d

(2) Maximum month peaking factor= 1.25

(3) Maximum day peaking factor= 2.0

(4) Peak hour flow peaking factor= 3.58

Table 5. Design Load Information

Parameter	Phase 1 Year 2020	Phase 2 Year 2030
Population	445	890
Per Capita BOD (kg/cap d)	0.080	0.080
Average BOD Load (kg/d)	36	72
Maximum Month BOD Load (kg/d)	45	90
Per Capita TSS (kg/cap d)	0.090	0.090
Average TSS Load (kg/d)	40	80
Maximum Month TSS Load (kg/d)	50	100
Per Capita TKN (kg/cap d)	0.022	0.022
Average TKN Load (kg/d)	10	20
Maximum Month TKN Load (kg/d)	12.5	25
Per Capita TP (kg/cap d)	0.003	0.003
Average TP Load (kg/d)	1.3	2.6
Maximum Month TP Load (kg/d)	1.7	3.4

Notes:

(1) Maximum month peaking factor= 1.25

(2) Maximum day peaking factor= 2.0

The flow and load data presented above, and the effluent quality criteria presented in Section 2.1 will form the basis of design for the examination of the secondary treatment technology options that will be discussed in Section 3.

2.3 SITE ISSUES AND CONSTRAINTS

In the Chatwin report, the proposed site for the wastewater treatment plant is located at the southern end of plan VIP2076 (Crown Lot 1 and 2), within the Village boundary. Eighty percent of this lot has been designated for senior housing, leaving approximately 0.28 hectares (2800 m^2) for implementing the Village's wastewater treatment plant. This area will also have to encompass any setbacks that may be required for the WWTP.

Given the proposed treatment plant's proximately to housing, odour control, noise abatement, and visual concealment will be key factors in the selection of the treatment processes and the ultimate design of the facility.

3. PROCESS ALTERNATIVES

3.1 INTRODUCTION

At the time of preparing this technical memorandum, the means of effluent disposal had not yet been determined due to the ongoing geotechnical evaluation of the proposed ground discharge site. As such, the sizing of process equipment and the plant layout will be based on the most stringent discharge requirements; that being a Class A effluent discharging to the ground. However, cost estimates will be prepared for both ground and marine discharge scenarios.

The heart of the plant will be the secondary treatment process. It is this part of the plant where we will discuss a number of feasible options. Each option will be required to treat to the wastewater based on the influent and effluent conditions described above in Section 2. The end goal will be to develop a facility that will serve the Regional District of Nanaimo (RDN) and the Village of Bowser well into the future. Evaluating each secondary treatment process will factor in several criteria that are important to the RDN and their wastewater operations staff.

3.2 COMMON TREATMENT PROCESSES

Secondary treatment is the segment of the overall treatment facility that will drive the other supporting unit process. Preliminary treatment, tertiary filtration, disinfection, and solids management are all influenced by the secondary treatment process selection.

For the comparison of secondary treatment technologies in this technical memorandum, common preliminary treatment, tertiary filtration (if necessary), disinfection, and sludge management processes have been used. During preliminary and detailed design these processes will be refined based on the selected secondary treatment option selected.

3.2.1 Preliminary Treatment

The preliminary treatment process that will be used for the Bowser WWTP will be made up of two mechanical screens; configured in a duty / standby arrangement. Mechanical fine screens are provided to remove large solids, rags and debris from the influent wastewater in an effort to protect downstream equipment. For a plant of this size, it is envisioned that either perforated plate or wedgewire screens will be used, depending on the degree of downstream protection required. If perforated plate screens are used, they will have a maximum opening size of 6mm, and will most likely be based on an auger screen design. This type of screen has an integral washing and compaction zone that creates an end product that will be amenable for landfill disposal. An example of this type of screen is provided in Figure 1. This type of screen can also come integrated in a stainless steel tank, which eliminates the requirement for the construction of concrete channels. This approach is commonly used for smaller facilities such as the Bowser WWTP.

Figure 1. Auger Screen (with integral screening bagger)

Should the secondary treatment unit process require a higher degree of screening, an option could involve the use of a rotary drum screen. These types of screens typically use wedgewire mesh as the screening media. In using this type of screen, opening sizes in the 0.5 to 2mm range are readily achievable. This type of screening technology is required to be used in conjunction with membrane bioreactor secondary treatment processes in order to protect the integrity of the membrane fibres.

Regardless of the screening technology to be utilized, it is assumed that odour control will be provided for the screenings building. This is typically one of the more odourous parts of the plant, and given the proximity to the Village it will be a key feature of the design.

Reference: Bowser WWTP – Treatment Technology Options Analysis

3.2.2 Tertiary Filtration

If the treatment facility is required to meet a Class A effluent quality, tertiary filtration will be required for the majority of the secondary treatment processes that are being considered (with the exception of MBR). Tertiary filtration will ensure that the effluent quality can readily meet the 10 mg/L concentration for both BOD_5 and TSS. If ultraviolet (UV) disinfection is selected for the facility, filtration will also increase the ultraviolet transmittance (UV_T) of the effluent, thus allowing the plant to more readily meet the challenging disinfection targets associated with Class A effluent. A higher UV_T value is indicative of a higher degree of clarity of the effluent. This further indicates that more of the UV light will be available for pathogen inactivation, as it will not be absorbed by interfering solids particles.

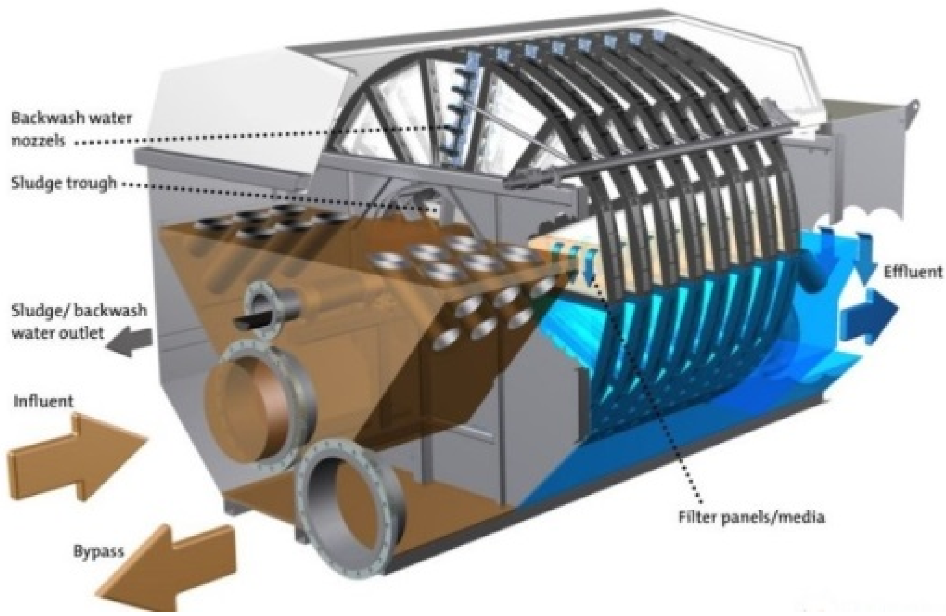
The tertiary filtration process that will be considered for this facility will be disc filtration. This type of filtration process has been used successfully at facilities throughout Western Canada. The process comes in one of two configurations:

1. Inside/out – this is the more commonly supplied technology where secondary effluent is introduced to the filter through a centre pipe. The secondary effluent then passes through the attached disc's filter media where it is then deposited into the filter basin prior to discharge. With this configuration, the filters are only partially submerged in the filter basin, and as such the head loss for these systems is normally lower. Backwash is accomplished by a spray system that sprays the outside of the filters; depositing the backwash debris into the centre half pipe where it is then conveyed away from the system, back to the head of the plant.

2. Outside/in – this is less commonly supplied, but there are several examples at facilities in Western Canada. These filters are completely submerged in the filter basin and allow the secondary effluent to pass from the outside of the filter inward towards a collection half pipe in the centre of the filter array. This half pipe then directs filtered effluent towards the effluent channel. Backwash is accomplished by suction shoes that are fitted to each disc in the filter array. Debris on the surface of the filter is sucked through the shoe via a pump and control valve arrangement. These filters require deeper basins than the inside/out filters and as such have a higher head loss. This technology is mechanically more complex with the vacuum backwash system.

Both discs rotate within the filter basin to ensure even exposure to the filter media. The filter media can be woven polyester media, stainless steel mesh, or polyester pile media. The nominal pore diameter of the filter media typically ranges from 5 to 15 microns. The disc arrays can be placed in cast in place concrete basins or in stand-alone stainless steel enclosures. Figure 2 illustrates the internal features of an inside/out filter configuration.

Figure 2. Disc Filter



3.2.3 Disinfection

To meet disinfection requirements ultraviolet (UV) disinfection will be utilized. Disinfection by a physical process such as UV eliminates the risks associated with chemical disinfection such as the need to generate, handle, transport or store hazardous chemicals. The UV system will consist of mercury arc lamps, a reactor and ballasts. The lamps can be contained in either an open channel or within a closed reactor vessel. As noted in the previous section, tertiary filtration will most likely precede the disinfection process as a means to increase the UV_T of the effluent. In the case of MBR technology, there are installations where disinfection has been excluded due to the fact that the ultrafiltration membrane material used for MBR can achieve pathogen concentrations below 2 MPN/100 mL. However, with the risk associated with maintaining constant membrane material integrity, the RDN may choose to keep the UV disinfection process as a back-up system.

3.2.4 Solids Management

For solids management, the proposed Bowser WWTP will utilize the same approach as that of the other smaller RDN wastewater treatment facilities (Nanoose and Duke Point). That being, waste solids will be collected and stored on site until it can be removed via vacuum truck and transported to the French Creek PCC for stabilization and disposal. Storage on site will consist of a two chambered concrete vault, complete with aeration. The aeration will be used to keep the contents mixed, while negating the onset of anaerobic conditions. The aeration will most likely be supplied as a branch line from the main secondary treatment process air system. A telescoping valve can also be added to each chamber to allow for periodic decanting in an effort to thicken the waste sludge prior to removal.

3.3 SHORTLISTED SECONDARY TREATMENT OPTIONS

We have opted to examine five secondary treatment processes that would be viable for the Bowser WWTP. These treatment options include:

1. Membrane Bioreactor (MBR),
2. Moving Bed Biofilm Reactor (MBBR) with tertiary filtration,
3. Sequencing Batch Reactor (SBR) with tertiary filtration,
4. Nitrifying / Denitrifying Activated Sludge with tertiary filtration, and
5. Upflow Sludge Blanket Filtration (USBF) with tertiary filtration.

Each process is described in the following sections.

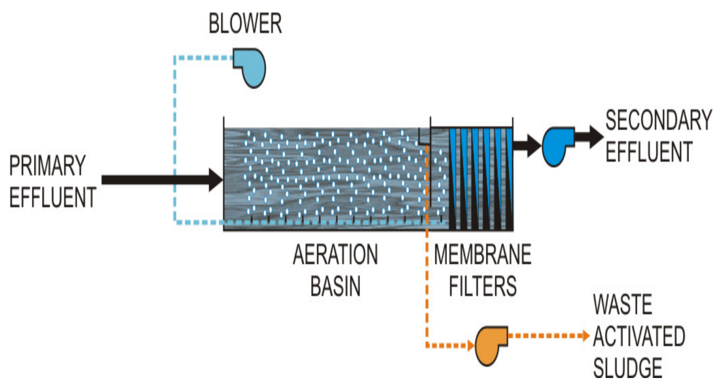
Aside from the distinct disinfection requirements, the main differences for the processes outlined above with regards to ground disposal versus marine discharge will be the requirement to nitrify and denitrify, as well as the degree of BOD and TSS reduction required. For ground disposal options, the secondary process will be required to reduce BOD and TSS by up to 95% and also be required to nitrify and denitrify the effluent prior to discharge. With a marine discharge, approximately 80% reduction of BOD and TSS is required, with no requirement for nitrification/denitrification. These differences will be reflected in the capital costs, as the ground discharge options will mostly require additional tankage and some added process components.

3.3.1 Membrane Bioreactor (MBR)

Membrane Bioreactors (MBR) combine a suspended growth biological reactor with solids removal via micro or ultrafiltration. The membranes are submerged in the final stage of the bioreactor train and are in direct contact with the mixed liquor. The membrane filtration equipment replaces the solids separation of secondary clarifiers in conventional wastewater treatment. Vacuum pressure is applied to a header pipe connected to the membranes to draw the treated effluent through the hollow fibre membranes and into the pump which transfers the secondary effluent (permeate) to the disinfection process or directly to the plant outfall. The external surface of the membrane is continuously scoured using airflow introduced at the bottom of the membrane module. The airflow also provides a portion of the biological process oxygen requirements. Excess biological sludge is wasted directly from the process tank or from the MBR tank. New generation membranes are cleaned in place using sodium hypochlorite and citric acid, therefore no removal of the membrane cassettes is normally required. Figure 3 shows a typical process flow diagram for MBR secondary treatment (does not reflect all configurations that would be required for the Bowser WWTP).

Reference: Bowser WWTP – Treatment Technology Options Analysis

Figure 3. Membrane Bioreactor Process Flow Diagram



MBR is a compact technology that is capable of producing a high quality effluent that is suitable for ground discharge without the requirement for tertiary filtration. Membrane filtration allows for a higher biomass concentration to be maintained (8,000 to 10,000 mg/L), reducing the required footprint for secondary treatment, as well as providing an environment that is conducive to nitrification/denitrification. However, this higher biomass concentration normally results in higher process air requirements, which in turn translates into higher energy consumption. MBR processes are also more energy intensive due to the pumping requirements and the energy required for backwashing and cleaning the membranes.

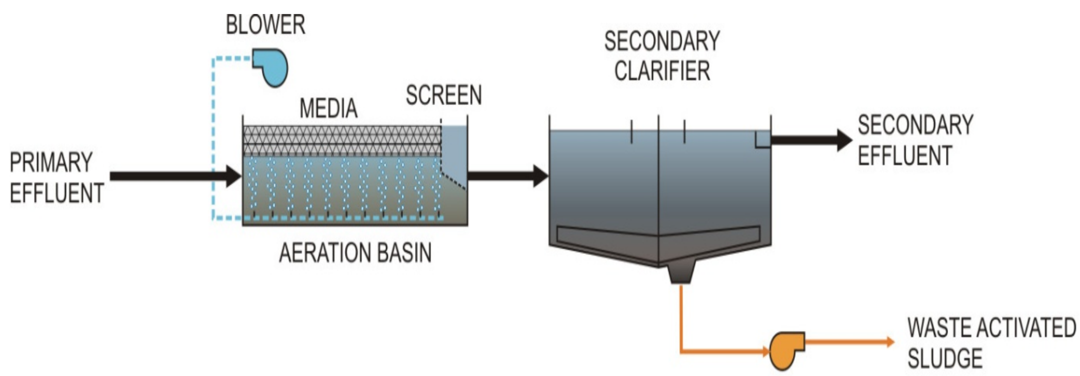
Operationally, the MBR process can be more complex and therefore somewhat more difficult to manage compared to conventional systems. However, process automation is a tool used for minimizing operator time and effort and if everything is operating properly minimal day to day intervention is required. Membrane bioreactors have proven to be a viable alternative to conventional treatment processes, and there are currently more than 100 WWTPs utilizing a MBR process in North America. One of the risks associated with the process is the chance that a membrane may fail while inside the reactor tank and draw in mixed liquor into the treated effluent. However, membrane failures can be detected by automated monitoring of the MBR effluent turbidity or monitoring the differential pressure across each membrane module to increase the system reliability. In addition to this, newer hollow fibre membranes are designed to reduce the risk of drawing in unfiltered mixed liquor.

Equalization is also normally required for the MBR as throughput is limited by the physical properties of the membranes and design flows can be no larger than 1.5 to 2 times the average design flow. Otherwise the process would have to be sized to meet all flow conditions, which would not be practical from either a cost or operating perspective.

3.3.2 Moving Bed Biofilm Reactor (MBBR)

Moving Bed Biofilm Reactor (MBBR) technology is a submerged attached growth process which uses a conventional bioreactor filled with carrier media suspended in the tank. The carrier media provides a surface for attached growth to take place and is kept suspended and in continuous movement with aeration or mixers. The carrier media is shaped to have a high surface area per unit volume and protect the biofilm from shear forces. A sieve is used to retain the carrier media in the bioreactor tanks. The MBBR system is a singles pass system with no return activated sludge (RAS) from the secondary clarifier or dissolved air floatation clarifier. MBBR systems provide a small footprint fixed film process that can meet high effluent standards when used in conjunction with tertiary filtration. Figure 4 shows a typical process flow diagram for MBBR secondary treatment (does not reflect all configurations that would be required for the Bowser WWTP).

Figure 4. Moving Bed Bioreactor Process Flow Diagram



MBBR systems are resilient, simple to operate and tolerate variations in loading. The biomass is retained in the MBBR tanks protecting the treatment system from toxic shock and washout during hydraulic peaks.

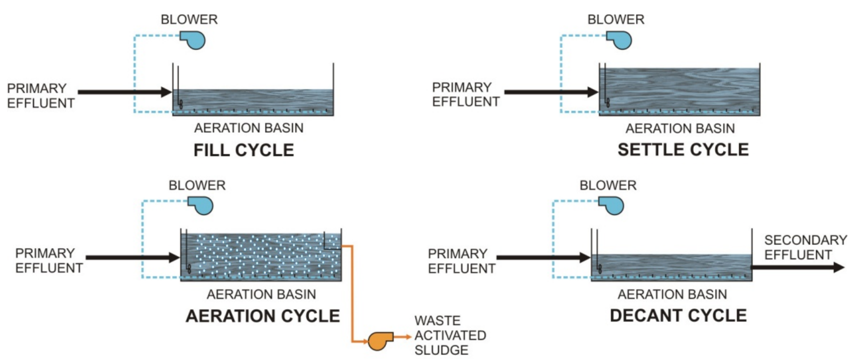
This is a relatively simple to operate process, along the lines of conventional activated sludge. Maintenance requirements are fairly low for this technology as the aeration system utilized must be very robust. This is due mainly to the fact that tank dewatering for inspection is a time consuming process as all of the suspended media would have to be removed to inspect the aeration grid at the bottom of the tank. For this reason, suppliers of this technology recommend stainless steel, medium bubble aeration systems compared to the PVC systems normally used in conventional activated sludge processes. Though more robust, this type of aeration system does require a slightly higher energy input compared to fine bubble systems used for the other secondary treatment process options being considered in this technical memorandum. Overall this technology is not as mature as more conventional treatment processes such as activated sludge, however there over 50 installations in North America; the majority of which are located in Quebec.

3.3.3 Sequencing Batch Reactor (SBR)

Sequencing Batch Reactor (SBR) is a modification of the conventional activated sludge process, whereby a single tank is used for both aeration and secondary clarification. Unlike conventional activated sludge in which flow moves continuously along a series of tanks, the SBR is a time-based batch system, which operates in a number of modes sequentially. A typical operating sequence for a SBR is composed of the following four stages to be carried out over a 4 hr period: fill, react (aeration or unaerated and mixed), settle (mixing/aeration off to allow solids to settle) and decant (clarified secondary effluent is drawn off). This is depicted in Figure 5. Sludge wasting is often conducted during the settle or idle phases but can occur in the other phases, depending on the mode of operation. For optimal process performance and redundancy a minimum of two reactors is recommended.

A variation of the conventional SBR is the continuous flow SBR; where influent flow is continual throughout all of the process cycle. This mode of operation allows for a smaller footprint relative to more traditional SBRs. The continuous SBR also has a small anoxic zone at the front of the reactor, which can allow the process to undergo a degree of denitrification (with mixed liquor recycle). This is beneficial should the process be required to meet Class A, ground discharge effluent requirements. Were this the case, the process would also require added tertiary filtration.

Figure 5. Sequencing Batch Reactor Process Cycle



SBRs can be advantageous over conventional activated sludge reactors as their reactors may require slightly less space because treatment takes place in a single basin instead of multiple basins and dedicated clarifier units. SBRs have a further advantage over activated sludge as the basins are all equally sized and common wall construction can be utilized. Operationally, the aeration and mixing devices are generally straight-forward to operate, however because of the sequencing nature of the process, the system is dependent upon automatic control to function. This is an increased level of complexity when compared to a more conventional system. The complexity will also increase for larger systems with more parallel units, and additional sophistication for the control system. The process can handle wide variations in feed characteristics and flow rates by varying process parameters such as: mixed liquor suspended solids (MLSS), solids retention time (SRT), sludge wasting rates, sludge settling, dissolved oxygen and air flow rates. As well, the timing of the different cycles can be modified to optimize the process, for example shortening up cycle times during peak flow events, or cycling air off and on for a nitrification/denitrification configuration.

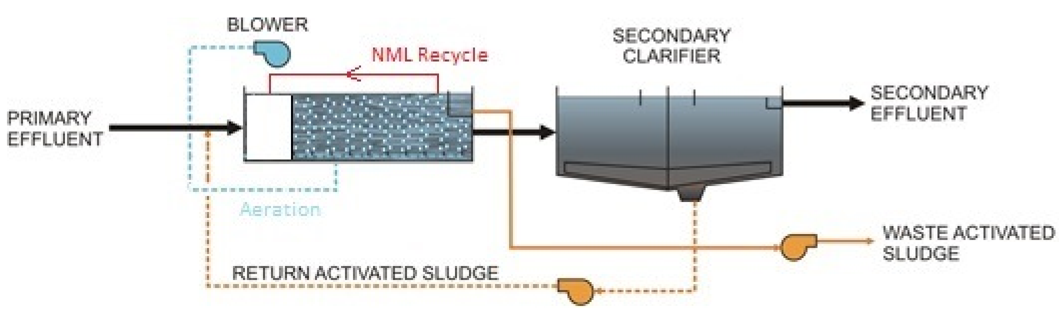
3.3.4 Nitrifying / Denitrifying Activated Sludge

The activated sludge process is one of the most widely used secondary treatment processes. It is a suspended growth process that utilizes gravity solids separation. Primary or preliminary effluent is directed to the aeration basin where it mixes with return activated sludge (clarifier underflow). The mixture (mixed liquor) is aerated and microbial activity occurs, breaking down the BOD (and if applicable, oxidizing the ammonia to nitrates). The aeration basin effluent (mixed liquor) is discharged to a secondary clarifier where the solids and liquid fractions are separated. Most of the sludge is returned to the aeration basin to provide the microbial community needed to remove organic contaminants from the influent. A fraction of the underflow (return activated sludge) or bioreactor's mixed liquor is wasted to offset biomass growth in the aeration basin and to control the solids retention time (SRT) in the system.

A variation of the conventional activated sludge configuration creates conditions to promote biological nitrification and denitrification. Nitrification is a two-step process in which ammonia is oxidized to nitrite and nitrite is oxidized to nitrate. Denitrification is the biological reduction of nitrate to nitric oxide, nitrous oxide and then nitrogen gas, thereby removing the nitrogen from the wastewater stream. The denitrification stage has proved to be a very effective method of eliminating the challenges of balancing dissolved oxygen concentrations at the front end of a conventional BOD removal plant when introducing rapidly biodegradable wastewater into the bioreactor, as the incoming wastewater is initially treated under anoxic conditions with nitrate (NO_3) and thus filamentous bacteria are not as prolific in this environment. Denitrifying bacteria are also known for their improved flocculation characteristics.

Compared to a conventional activated sludge process, the nitrifying/denitrifying configuration will have a larger bioreactor, and a mixed liquor recycle pump that would not be required with a basic BOD removal plant. The larger bioreactor will allow the system to operate with a longer solids retention time, thereby developing the nitrifying bacteria in the aerobic zones over a wide range of wastewater temperatures. The nitrate-rich mixed liquor is recycled continuously from the back end of the bioreactors to the front of the bioreactors (anoxic zone). The anoxic zone (an un-aerated and mixed front portion of the bioreactor) allows the denitrifying bacteria to develop reducing the concentration of nitrate in the system. The combination of nitrate (NO_3), denitrifying bacteria and an un-aerated zone will also result in significant soluble $cBOD_5$ removal. Figure 6 illustrates the basic configuration of the nitrifying /denitrifying activated sludge process. The nitrifying/denitrifying configuration will only be required for ground discharge where there is a total nitrogen limit. A conventional BOD removal only process will be adequate for marine discharge.

Figure 6. Nitrifying / Denitrifying Activated Sludge Process Flow Diagram



3.3.5 Upflow Sludge Blanket Filtration (USBF)

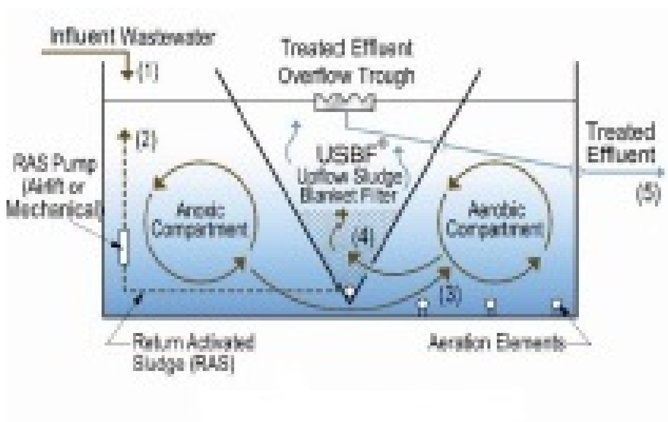
Upflow Sludge Blanket Filtration (USBF) has been selected as part of this options analysis mainly due to the fact that there is a relatively large reference base for this technology on Vancouver Island. It has been used primarily for residential developments and First Nations developments.

Reference: Bowser WWTP – Treatment Technology Options Analysis

Biological treatment takes place in a USBF bioreactor that consists of an anoxic zone, an aeration zone and a sludge blanket filter. Screened influent is pumped from an equalization tank into the anoxic zone, where it is mixed with return activated sludge (RAS) from the bottom of the sludge blanket filter. From the anoxic zone the mixed liquor flows to the aerobic zone, which is equipped with fine bubble diffusers for the supply of process air to the reactor. Aerated and moved in a plug flow manner, mixed liquor eventually enters the bottom of the sludge blanket filter. The mixed liquor enters the sludge blanket filter at the bottom and, as it rises, upward velocity decreases until the flocs of cells become stationary and thus form a filtering media. A high degree of filtration efficiency is achieved as colloid and very fine particles are filtered out. As the floc becomes large and heavy, it settles to the bottom of the sludge blanket filter and is subsequently recycled back into the anoxic compartment as RAS. Treated effluent is collected in a trough on top of the sludge blanket filter before flowing by gravity to a filter feed tank, which is then followed by a sand filter. Figure 6 depicts the flow through the USBF process.

Like the continuous flow SBR, this process is configured to allow for denitrification to occur within the reactor, thus making the effluent amenable for ground discharge. The influent that is mixed with the RAS in the anoxic compartment provides the carbon source needed for denitrification.

Figure 7. Upflow Sludge Blanket Filtration Process Schematic[3]



3.4 SECONDARY TREATMENT PROCESS EQUIPMENT AND OPERATING COSTS

For each of the secondary treatment process options discussed above, a capital cost for each process has been developed (Table 6). This cost only includes the process equipment and concrete structures, as applicable. The estimate does not include process equipment that would be common to all of the processes, such as screening, disinfection and sludge storage. A whole plant cost estimate for the selected technology will be discussed further in Section 4. Vendor quotations were utilized to develop the costs for the MBR, MBBR and USBF process, where in-house cost estimates were used for the SBR and Nit/Denit AS.

Table 6. Process Capital Costs

[3] USBF process schematic provided by ECOFluid.

Process	Phase I (Ground Discharge)	Phase I (Marine Discharge)	Phase II Expansion Costs	Phase II (Ground Discharge)	Phase II (Marine Discharge)
MBR	$965,000	$905,000	$500,000	$1,465,000	$1,405,000
MBBR	$950,000	$650,000	$600,000	$1,505,000	$1,250,000
SBR	$645,000	$525,000	$495,000	$1,140,000	$1,020,000
Nit/Denit AS	$820,000	$740,000	$330,000 – $630,000	$1,450,000	$1,070,000
USBF	$410,000	$410,000	$350,000	$760,000	$760,000

For each of the secondary treatment process options discussed above, an annual operating cost has been developed (Table 7). As noted, these include maintenance, labour, power, sludge management, and environmental (lab) annual costs.

Table 7. Annual Operating Costs

Process	Disposal Option	Maintenance	Labour	Power	Sludge Management	Environmental	TOTAL
MBR	Marine	$18,000	$57,000	$9,800	$53,000	$5,000	**$142,800**
	Ground	$19,300	$69,000	$14,000	$52,000	$7,000	**$161,300**
MBBR	Marine	$13,000	$43,000	$8,500	$56,000	$5,000	**$125,500**
	Ground	$15,000	$49,000	$11,800	$53,000	$7,000	**$135,800**
SBR	Marine	$10,500	$45,000	$7,400	$56,000	$5,000	**$123,900**
	Ground	$12,000	$51,000	$9,800	$53,000	$7,000	**$132,800**
Nit/Denit AS	Marine	$12,600	$51,000	$7,400	$56,000	$5,000	**$132,000**
	Ground	$14,000	$54,000	$9,800	$53,000	$7,000	**$137,800**
USBF	Marine	$8,200	$51,000	$7,400	$56,000	$5,000	**$127,600**
	Ground	$9,400	$52,000	$9,800	$53,000	$7,000	**$131,200**

The information provided in Tables 6 and 7 will be carried forward and used for the evaluation of the five proposed secondary treatment processes.

4 EVALUATION

4.1 METHODOLOGY

The intent of the evaluation methodology is to utilize not only economic factors, but also specific non-economic factors that we have assumed will be of importance to the RDN. Table 8 outlines the factors that will be used to evaluate the various technologies, along with a description of each. For each factor, we have also developed a weighting that will be used in the evaluation of the secondary treatment process options. This weighting has been used by other municipalities that we have worked with for similar process selection exercises.

Table 8. Evaluation Criteria and Weightings

Criteria	Description	% Weighting
Capital Cost	Construction costs	15
Operating Cost	Annual operating costs	25
Expandability	The flexibility to expand the process to meet future growth.	5
Future Regulations	The flexibility of the secondary process to meet future regulatory requirements.	10
Integrated Resource Recovery	The potential for the secondary treatment process to offer IRR opportunities (effluent re-use, biosolids re-use, heat recovery, etc.)	5
Land Area	Total relative footprint of land area required for the complete treatment plant.	5
Odour Potential	Potential for odour to be generated in the secondary process.	15
Reliability	Performance experience in similar climates and similar plant sizes.	10
Robustness	Ability to handle changes in flow and load without impacting effluent quality.	10

4.2 SCORING AND OPTIONS EVALUATION

For each of the criteria associated with each of the secondary treatment process options, a score between one and five has been developed as noted below in Table 8. Each score is defined as follows with respect to relative performance associated with each criterion: 1- poor, 2 – satisfactory, 3 –good, 4 – very good and 5 – excellent.

Table 8. Secondary Treatment Process Options - Weighted Scores

	MBR		MBBR		SBR		Nit/Denit AS		USBF	
Criteria (Weighting)	**Score**	**Weighted Score**	**Score**	**Weighted Score**	**Score**	**Weighted Score**	**Score**	**Weighted Score**	**Score**	**Weighted Score**
Capital Cost (15%)	2	0.3	3	0.45	4	0.6	3	0.45	5	0.75
Operating Cost (25%)	2	0.5	4	1	5	1.25	3	0.75	4	1
Expandability (5%)	4	0.2	5	0.25	3	0.15	3	0.15	3	0.15
Future Regulations (10%)	5	0.5	3	0.3	3	0.3	3	0.3	3	0.3
IRR (5%)	5	0.25	4	0.2	4	0.2	4	0.2	4	0.2
Land Area (5%)	5	0.25	4	0.2	4	0.2	2	0.1	3	0.15
Odour Potential (15%)	4	0.6	4	0.6	4	0.6	4	0.6	4	0.6
Reliability (10%)	4	0.4	3	0.3	4	0.4	4	0.4	2	0.2
Robustness (10%)	4	0.4	5	0.5	5	0.5	4	0.4	4	0.4
TOTAL		**3.40**		**3.80**		**4.20**		**3.35**		**3.75**

Reference: Bowser WWTP – Treatment Technology Options Analysis

Some of the strong and poor performers for each criterion are explained as follows:

1. Capital Cost – this was taken as a direct comparison from Table 6 of the Phase I average costs for the ground and marine discharge options. In this case, the USBF process provided the lowest capital cost, where the MBR process provided the highest.
2. Operating Cost – this was taken as a direct comparison from Table 7 of the average operating costs for the ground and marine discharge options. In this case, the SBR process provided the lowest operating cost, where the MBR process provided the highest. MBR did not perform as well in this category due to the higher energy costs associated with running the process air system at higher mixed liquor concentrations. It also requires cleaning chemicals which also adds to the annual operating costs.
3. Expandability – The MBBR process scored the highest for expandability as no additional tankage or costly process equipment is required to bring the process from Phase I to Phase II. The only cost would be associated with adding additional media to the bioreactors to bring the loading factor up to its maximum level. Both SBR and UFSB would require duplicate process trains to make the transition from Phase I to Phase II.
4. Future Regulations – The MBR process produces the highest quality effluent and is therefore most likely of the four processes to be able to adapt to future effluent requirements.
5. IRR Potential – The MBR process offered the best potential for IRR based on the high quality effluent it produces. This effluent could be used for irrigation and heat recovery.
6. Land Area – Based on the area of tankage required for the four secondary treatment processes, the MBR process offered the smallest footprint and thus scored the highest.
7. Odour Potential – None of the four secondary treatment processes will produce a significant quantity of offensive odour, and as such they scores equally high for this criterion.
8. Reliability – The MBR, activated sludge, and SBR process scored equally in this criterion given the fact that there are more reference plants throughout Canada relative to MBBR and USBF, and the RDN has operational experience with both (SBR – Duke Point PCC and MBR – Church Road Solid Waste Transfer Station).
9. Robustness – On their own, the SBR and MBBR process are best equipped to handle fluctuations in flow and load as they do not require flow or load equalization up stream of the main secondary treatment unit process. Both MBR and USBF both require upstream equalization in order to keep the main process size reasonable.

4.3 RECOMMENDED SECONDARY PROCESS

Based on the weighted scores generated in Table 8, SBR is best suited for use as the secondary treatment process for the Bowser WWTP. As noted above, the RDN is familiar with this technology having operated a similar continuous flow SBR at the DPPCC since 1997. This technology lends itself well to a site that will not be manned on a continual basis. The control system is such that it can adapt to changing flow conditions without the need for any operator adjustments. There are several examples of similarly sized facilities throughout North America that require minimal operator attention. The SBR's rectangular tank construction allows for the use of common walls for several of the unit processes, and therefore a consequential ease of constructability. Allowance during design can be made for the expansion of the plant through the addition of more rectangular SBR tanks using the common wall approach.

4.4 COST ESTIMATE

A cost estimate has been developed for the Bowser WWTP using SBR as the basis of secondary treatment (Table 9).

Table 9. Bowser WWTP Capital Cost Estimate

General Requirements	$125,000
Civil	$130,000
Structural	$831,250
Process	$1,176,000
Building Mechanical	$175,000
Electrical / Instrumentation	$225,000
Sub-total	$2,662,250
Contingency	$931,500
TOTAL	**$3,600,000**

The cost estimate assumes the following:

1. General requirement costs include mobilization, start-up and commissioning, O&M manuals and demobilization.

2. Civil costs include site preparation and yard piping.

3. Structural costs include all process tanks and buildings. The building is assumed to have a modest architectural look given the potential proximity to the town site.

4. Process costs include all unit process equipment, installation and interconnecting piping and valves.

5. Building mechanical includes odour control, heating and ventilation, and domestic plumbing.

6. Electrical and instrumentation includes the primary feed, lighting, control hardware and programming. Emergency power has not been included in the estimate.

7. A contingency of 35% has been included as this project requires an estimate that is somewhere between a Class 4 and Class 5 Opinion of Probable Cost.

STANTEC CONSULTING LTD.

Prepared by ______________________________
(signature)
David Lycon, Ph.D., P.Eng., PE

Reviewed by ______________________________
(signature)
Bob Dawson, Ph.D., P.Eng.

Technical Memo 2 Rev 2

To:	Regional District of Nanaimo Gerald St. Pierre, P.Eng.	From:	Stan Spencer, P.Eng. Stantec – Victoria Office
File:	111700522	Date:	April 25, 2016

Reference: Bowser WWTP – Effluent Disposal Options Analysis (Outfall vs. Ground) Rev. 2

1. INTRODUCTION

1.1. BACKGROUND

As part of the development of the preliminary design for the Bowser Village Centre Wastewater Service Project, a review of wastewater treatment effluent disposal options must first be undertaken. This analysis will provide a recommendation for the preferred disposal option to allow the Regional District of Nanaimo to obtain a Discharge Certificate as defined in the BC Municipal Wastewater Regulation.

For the ground disposal option, Stantec contracted WSP Canada Ltd, (formerly Levelton Consultants) to conduct field investigations and testing to determine the suitability of the sites identified in the Feasibility Study for Area-H Bowser Community Sewer Servicing Study (Chatwin Engineering 2011) for ground disposal. For the marine outfall option, Great Pacific Engineering was retained to undertake a feasibility analysis of an ocean outfall and identify constraints that may be expected for this solution.

Recent work which was reviewed in the preparation of this technical memorandum includes:

- Regional District of Nanaimo RFP - Engineering Services — Bowser Village Centre Wastewater Service: Collection, Treatment, and Disposal Project; and
- Feasibility Study for Area-H Bowser Community Sewer Servicing Study (Chatwin Engineering 2011).

1.2. OBJECTIVE

The objective of this technical memorandum is to integrate the conclusions of these independent evaluations and provide RDN with a recommendation for the preferred disposal option which will be used as the basis for the preliminary and detailed design of the wastewater treatment plant.

2. DESIGN CONSIDERATIONS

2.1. REGULATORY REQUIREMENTS

The regulatory guidelines to be used as a basis for this project come from the British Columbia Environmental Management Act's *Municipal Wastewater Regulations (MWR)* and the federal *Wastewater Systems Effluent Regulation* (*WSE*R). These regulations set the requirements for treatment plant effluent quality, depending upon on the nature of the discharge environment.

Reference: Bowser WWTP – Effluent Disposal Options Analysis (Outfall vs. Ground) Rev. 2

The *MWR* regulates minimum effluent quality and outfall design criteria based on the properties of the receiving environment and effluent flow rates. The study area is located in what is considered embayed marine water as defined by the MWR. That is to say that the proposed discharge will be located on the shore side of a line less than 6 km long drawn between any 2 points on a continuous coastline.

The WSER establishes minimum effluent criteria for all discharges with flows greater than100 m^3/day. There is no association to specific receiving environment conditions under the WSER.

Both of the proposed disposal options require a distinct effluent quality, and as such will have a bearing on the final treatment technology selected.

2.2. MUNICIPAL EFFLUENT CLASSES

From Section 69, *Environmental Management Act, Municipal Wastewater Regulation B.C. Reg. 87/2012 O.C. 230/2012*, municipal effluent is classed as follows:

> Class A, being high quality municipal effluent resulting from advanced treatment with the addition of disinfection and nitrogen reduction;
> Class B, being high quality municipal effluent resulting from advanced treatment;
> Class C, being municipal effluent resulting from secondary treatment;
> Class D, being municipal effluent resulting from treatment in a septic tank.

The anticipated Maximum Day effluent flow rate is anticipated to be 640 m^3/d.

2.3. EFFLUENT CRITERIA FOR GROUND DISCHARGES

Section 76 of the *Municipal Wastewater Regulation* defines minimum unsaturated soil depth for ground discharge systems. Unsaturated soil means the soil between the land surface and the water table where the soil pore spaces contain water at less than atmospheric pressure, as well as air and other gases.

1. For class A or B municipal effluent, a discharger must ensure that the minimum unsaturated soil depth is 0.5 m.

2. For class C or D municipal effluent, a discharger must ensure that the minimum unsaturated soil depth for maximum daily flows of

   (a) less than 37 m^3/d is 0.75 m, and
   (b) 37 m^3/d or more is 1 m

Table 1 - Effluent Criteria-Ground Discharge			
Requirement	**Class A**	**Class B**	**Class C**
BOD5 (mg/L)	10	10	45
TSS (mg/L)	10	10	45
Fecal coliform (MPN / 100 mL)	Average: 2.2 any sample: 14	400, if maximum daily flow is ≥ 37 m3/d	n/a
Turbidity (NTU)	Average: 2 any sample: 5	n/a	n/a
Nitrogen (mg/L)	Nitrate-N:10 total N: 20	n/a	n/a

The differentiation between Class A and Class B effluent relates to the proximity of the wastewater ground discharge to a drinking water source's zone of influence. If the discharge is within 300 meters of the drinking water source's zone of influent, the effluent must meet Class A requirements.

To meet the requirements of Section 76 of the MWR for ground discharge, the effluent requirement would be Class A.

2.4. DRAINAGE PIPE LENGTH AND LAND REQUIREMENTS

Section 78(1) of the MWR specifies that a discharger must ensure that drainage pipes are at least the length set out for the applicable municipal effluent class and percolation rate, as listed in Table 2

Table 2 - Minimum Drainage Pipe Length for Each Field							
	Metres of drainage pipe for each 10 m³/d of maximum daily flow for percolation rates shown						
percolation rate (minutes/25 mm)	2	5	10	15	20	25	30
Class A, B or C municipal effluent	50	75	100	110	120	135	150
Class D municipal effluent	120	215	280	320	360	400	430

For the anticipated Maximum Day effluent flow rate of 640 m^3/d, 3,200 m to 9,600 m of drainage pipe would be required depending on the percolation rate of the receiving ground.

Section 82(2) of the MWR specifies that:

a) drainage pipes are provided in 2 drain fields, each having at least the length of drainage pipe required under section78 *[drainage pipe length requirements]* unless a reduction is permitted under section 79 *[reductions in drainage pipe length]*;
b) a third undeveloped drain field is retained as a standby area;
c) drain fields are constructed with trenches spaced
   (i) such that there is at least 3 m between the centre of each trench, or
   (ii) if the performance of the drain field would not be adversely affected, at least 2 m apart from each other with at least double the standby area;

Applying these criteria, a ground disposal area of 2.88ha to 8.64 ha would be required for an in ground disposal system depending on the percolation rate of the soil.

2.5. EFFLUENT CRITERIA FOR MARINE DISCHARGES

The proposed wastewater treatment system and the associated marine outfall will be designed, constructed, and operated in compliance with both the BC *Municipal Wastewater Effluent Regulation (MWR)* and the federal *Wastewater Systems Effluent Regulation (WSE*R).

The *MWR* regulates minimum effluent quality and outfall design criteria based on the properties of the receiving environment and effluent flow rates. The study area is located in what is considered embayed marine water as defined by the WMR. That is to say that the proposed discharge will be located on the shore side of a line less than 6 km long drawn between any 2 points on a continuous coastline.

The WSER establishes minimum effluent criteria for all discharges with flows greater than 100 m^3/day. There is no association to specific receiving environment conditions under the WSER.

The minimum effluent criteria for MWR and WSER are outlined inTable 3 below.

Table 3 - Effluent Criteria-Marine Discharge			
MWR Criteria – Embayed Marine Waters		WSER	
Parameter	**Criteria**	**Parameter**	**Criteria**
Toxicity	Effluent is not acutely lethal[1]	Toxicity	Effluent is not acutely lethal[1]
BOD_5	< 45 mg/L (maximum)	$cBOD_5$	< 25 mg/L (average)
TSS	< 60 mg/L (maximum)	TSS	< 25 mg/L (average)

Reference: Bowser WWTP – Effluent Disposal Options Analysis (Outfall vs. Ground) Rev. 2

Table 3 - Effluent Criteria-Marine Discharge			
pH			
Total phosphorus (P)			
Ortho-phosphate as (P)			
Ammonia Nitrogen	Based on receiving water characteristics[2]	Un-Ionized Ammonia (as Nitrogen)	1.25 mg/L (maximum at 15˚C ± 1˚C)
Fecal Coliforms	Based on receiving water usage[3]		
Total Residual Chlorine	<0.02 mg/L (maximum)	Total Residual Chlorine	<0.02 mg/L (average)

1. Effluent standards for ammonia nitrogen are based on the predicted dilution within the effluent plume at the boundary of the Initial Dilution Zone (IDZ). The IDZ is defined in the MWR as a cylindrical volume of water centered on the terminus of the outfall with a radius that is the lesser of 100 m or 25% of the width of the body of water; the cylinder extends from the seafloor to the surface of the water.
2. The allowable ammonia nitrogen concentration is based on back calculations of water quality guidelines and the predicted dilution of the effluent plume at the boundary of the IDZ. The most stringent water quality guideline, for the proposed discharge, is the average 5 to 30 day concentration of total ammonia nitrogen for the protection of marine life (MOE 2001). The applicable guideline is based on a pH of 8.4 (MOE 2001), a minimum salinity of 20 g/kg, and a maximum temperature of 15°C. In this case, the most stringent water quality guideline for ammonia nitrogen at the edge of the IDZ is 0.59 mg/L.
3. The allowable effluent fecal coliform concentration is back calculated from the predicted dilution at the boundary of the IDZ and any sensitive areas, and is based on the allowable fecal coliform concentration for these areas. The allowable fecal coliform concentration is dependent on the water based activities in the area of the discharge.

   For discharges to recreational use waters, the applicable water quality standard states that the number of fecal coliform organisms outside the IDZ must be less than 200 MPN /100 mL. Recreational usage is considered as any activity involving the intentional immersion (e.g., swimming) or incidental immersion (e.g., waterskiing) of the body, including the head, in natural waters" (Health and Welfare Canada 1992).
4. For discharges to shellfish bearing waters the applicable water quality standard is median or geometric mean of less than 14 MPN/100 mL at the edge of the IDZ (Canadian Food Inspection Agency 2008). For the purpose of this regulation, shellfish water means water bodies that "have or could have sufficient shellfish quantities that recreational or commercial harvesting would take place or water for which commercial shellfish leases have been issued" (WLAP 1999). Shellfish are defined as: "all edible species of oysters, clams, mussels and scallops either shucked, in the shell, fresh or fresh frozen or whole or in part. For the purposes of marine biotoxin control, predatory gastropod molluscs shall also be included" (Canadian Food Inspection Agency2008).

Reference: Bowser WWTP – Effluent Disposal Options Analysis (Outfall vs. Ground) Rev. 2

3. SUMMARY OF GEOTECHNICAL INVESTIGATION OF GROUND DISPOSAL OPTIONS

3.1. DISCUSSION AND RECOMMENDATIONS

The following sections are a summary of the geotechnical investigations completed by WSP attached in Appendix A of this Technical Memorandum

3.2. GENERAL

The primary intent of the current geotechnical assessment was to complete a desktop study of available information relating to the general subsurface ground conditions in the local area in relation to the potential suitability for in-ground disposal of treated wastewater. The results of the information review were to be used by the RDN and Stantec as part of the decision making process in determining whether to proceed with the development of an in-ground system or to focus efforts towards an alternative marine disposal system.

In 2011, Chatwin Engineering Ltd completed a *Feasibility Study for Area-H Bowser Community Sewer Servicing Study* for RDN and concluded that there was potential for a ground disposal option in 2 areas described below (from Chatwin 2011 report) and illustrated in Figure 1 on page 7:

Area-1 Crown Land within Bowser Village

The soil conditions of this site were only suitable for a maximum of discharge of 22.7m3/d. The area has a high water table, the depth of soil suitable for infiltration is shallow. Hence, the lot area was insufficient for larger sewage flows. In addition, active water wells exist close to this area; therefore the setbacks reduce the area of land available for ground disposal.

Area-2 Site adjacent to the Inland Island Highway

This site has good potential for ground disposal and can handle the projected sewage flows of 320 m^3/day. This site is about 2.5Km from the treatment plant and is approximately 40m higher in elevation than the treatment plant site. Based on the broad assessment, the estimated land area required for disposing 320m3/d average dry-weather flows is 3.2ha; this includes 10 active and 10 reserve infiltration basins and additional areas to align the basins and accommodate equipment and accessibility. Moreover, the site is constrained by Thames Creek from the North, thus appropriate setbacks needs to be established based on the level of sewage treatment.

Following an initial site reconnaissance in November 2015, WSP attempted to obtain permission to enter the Crown Lands for purposes of exploration from the BC Ministry of Forests, Lands and Natural Resource Operations through FrontCounter BC. At that point, it was indicated that the entire area lies within a Coastal Douglas Fir (CDF) Conservation Area (Figure 1) and that any exploration or development was prohibited by statute. Following this discovery, it was confirmed by the RDN that Area 1 had been exempted from the protectedarea through a lease agreement with the Province but that Area 2 was effectively off limits.

Since that time, two alternative in-ground disposal sites were identified (shown on below). The first was to the southof the village near the BC Hydro transmission line right-of-way at Nile Creek(Area 3).

The second was to the west of the village, on the site of an existing seedling orchard (Area 4). It is understood that these sites are outside of the CDF protection zone.

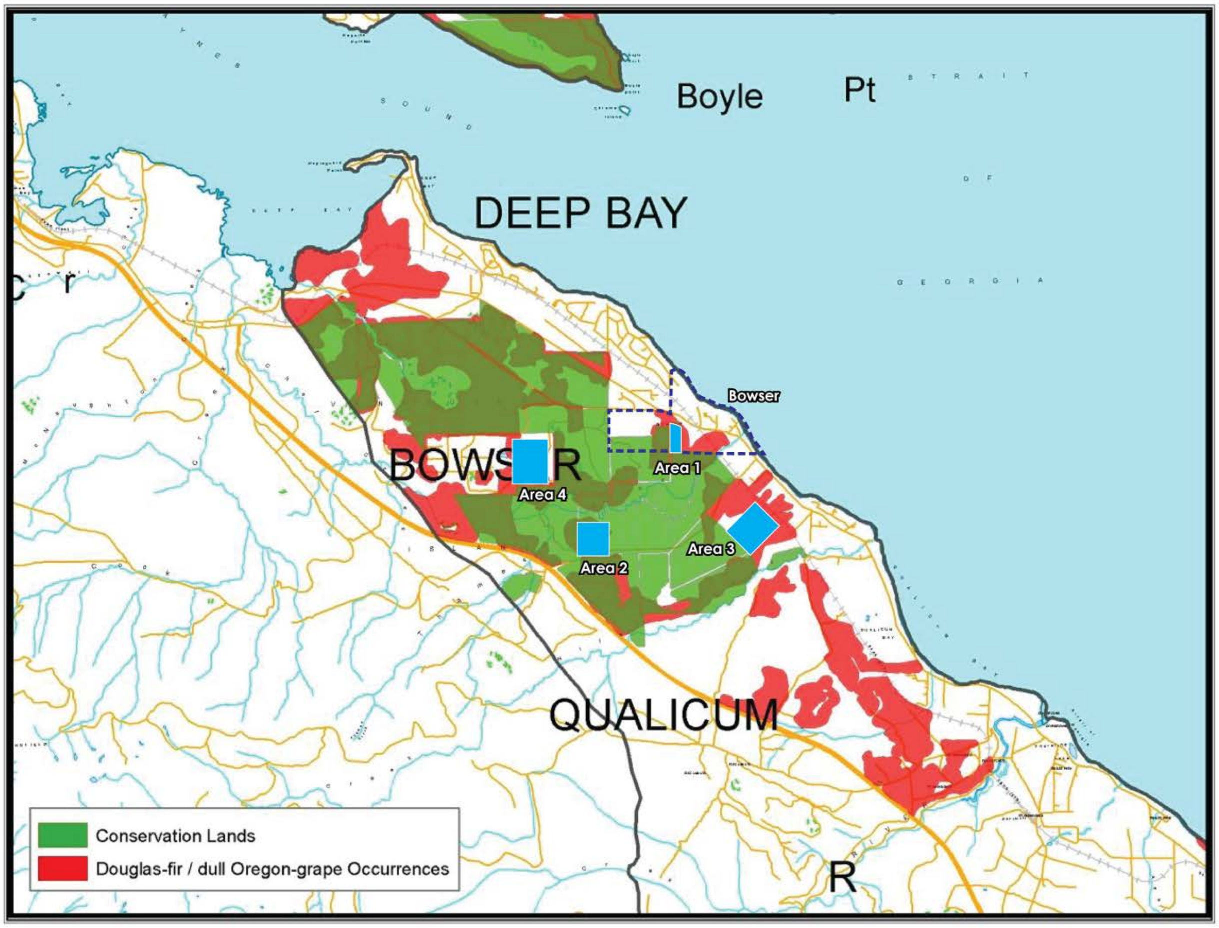


Figure 1 - Coastal Douglas Fir Conservation Area

5.2 GROUND DISPOSAL SITES

The information review indicated that the project area is generally underlain by a veneer of marine deposits overlying shallow glacial till that extends several tens of metres below ground surface prior to contacting the Quadra Sediments. In general, glacial till tends to be relatively impermeable, is not conducive to infiltration of surface water, and is not considered suitable for development of in-ground disposal fields.

Local evidence of this condition was indicated from a field visit to the second alternative disposal site near the powerline right-of-way where areas of ponded or standing water were observed and substantial runoff or overland flow was occurring after rainfall. Both of these phenomena indicate that there was very little infiltration of the rain fall likely due to the restricting presence of the glacial till.

The marine veneer/glacial till condition is prevalent over the majority of the local area. It is also shown to underlie the seedling orchard area to the west. Given the required capacity of the proposed system indicated by Stantec, it does not appear that the local surficial geology would be suitable for development of an in-ground system. As such, from a geotechnical perspective, marine disposal should be considered as an alternative.

The geotechnical investigations do not address the impact of ground disposal of treated effluent on the local ground water (aquifer). Ground water impacts are addressed through the MWR which prescribes treatment standards for effluent depending on proximity of discharges to groundwater supply sources. These criteria are described in Section 2.3 of this Technical Memorandum. If the discharge is within 300 meters of the drinking water source's zone of influent, the effluent must meet Class A requirements.

3.3. TREATMENT PLANT

Interpretation of the results of the background review, field reconnaissance, and the subsurface probing with the WCT has indicated that the proposed treatment plant site is underlain by shallow, competent, glacial till soil that would be expected to provide suitable bearing support for the treatment plant building and associated equipment.

The WCP – and observations of local soil exposures – indicated that the consistency of the silt till was 'very dense' or 'hard'. For the purposes of preliminary foundation design, an allowable bearing capacity for footings sitting directly on a subgrade of undisturbed till would be in the order of 250 kPa.

The review of local waterwell logs indicated that descriptions of "till" soils extended to depths of more than 50 m. Under this condition, the treatment site could be considered as a seismic Site Class 'C' according to the 2012 BC Building Code.

Under the interpreted conditions, general site preparation for the treatment plant site would involve clearing of vegetation and stripping of surficial topsoil and the veneer of sand and gravel to expose an undisturbed subgrade of intact till. If necessary, design grades could be raised through the placement of engineered fill bearing on an approved subgrade of till

The mapping indicates that the shallow till extends essentially to the shoreline through the project area and, as such, would likely form the subgrade for the collection and conveyance system. Note, however, that structures at the shoreline could be underlain by the Salish Sediments atop the till and could be subject to adverse geotechnical constraints such as bearing capacity and poor seismic response. Once the configuration of this part of the system has been confirmed, these area should be subject to site specificsubsurface investigation for input to detailed design.

4. SUMMARY OF INVESTIGATION OF MARINE DISPOSAL OPTIONS

This following sections are a summary of findings completed by Great Pacific and contained in Appendix B of this Technical Memorandum

4.1. CONCLUSIONS AND RECOMMENDATIONS

The marine environment at Bowser is capable of accepting treated wastewater. The marine environment in this area is expected to have a high assimilative capacity due to ocean volume and tidal action for mixing and dispersion, and presence of marine microorganisms and physicochemical processes for nutrient breakdown. The preferred outfall alignment is Option A as presented in Figure 2 below, and the discharge zone is considered to be robust.

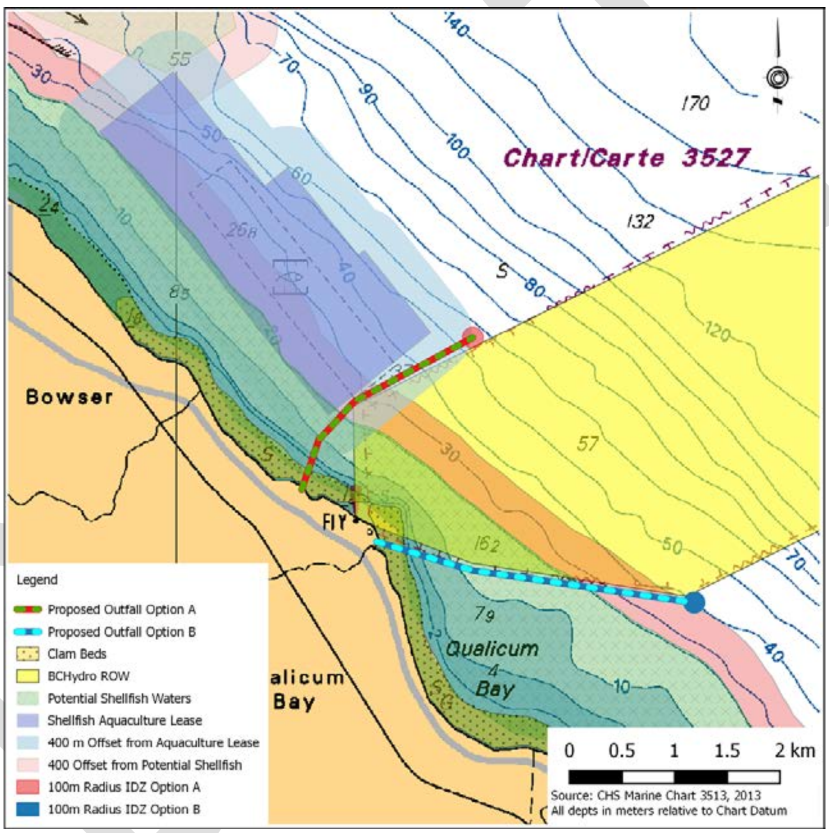


Figure 2 - Marine Outfall Options (from Great Pacific report - Appendix B)

Due to the proximity and importance of shellfish resources in the vicinity, the effluent will need to be disinfected.

Despite the additional cost, an outfall diameter of 200 mm is recommended as the future flow projections have only been completed to the year 2030, just 15 years from now. Typically, a municipal marine outfall would be designed for at least 40 years, and the flows are predicted to

Reference: Bowser WWTP – Effluent Disposal Options Analysis (Outfall vs. Ground) Rev. 2

continue to increase beyond year 2030. The practical life of a marine outfall could extend beyond a 50 year design horizon.

4.2. PERMITS

The permits and approvals relevant to the marine outfall include:

- Navigation Protection Act;
- Fisheries Act;
- Crown land tenure; and,
- Municipal Wastewater Regulation Registration or Liquid Waste Management Plan Amendment.

4.3. RECOMMENDED INVESTIGATIONS

Detailed design of the marine outfall will require the collection of site specific environmental data. There is insufficient information related to the oceanographic, geotechnical, and archeological conditions along the proposed route.

Oceanographic studies will be required as part of the design phase for the marine outfall. Currents and water column properties in the vicinity of the discharge should be confirmed. Accordingly, the recommended studies include:

- Baseline water quality sampling (fecal coliforms & enterococci);
- Collection of water column profiles;
- Current measurements (drogue study or current profiler); and,
- Detailed bathymetric and backshore survey to delineate the topography of the backshore and foreshore seabed.
- Geotechnical investigations are also recommended and would include a combination of the following:
  - Diver and Remotely Operated Vehicle (ROV) surveys to visually assess seabed/substrate characteristics and potential pipeline hazard areas such as sunken logs; and,
  - Intertidal investigations to characterize sediment depth and composition.
- The presence and inventory of sensitive habitats (e.g. eelgrass) along the preferred route and proximity to shellfish beds will also be needed.
- An archeological review along the proposed route is recommended to investigate the potential for archaeologically significant materials.

Communication with stakeholders should also be conducted in advance of completing the detailed design.

4.4. RISKS AND RISK MITIGATION

The site selection of a new outfall comes with potential risks. These are primarily associated with permitting and stakeholder engagement.

Reference: Bowser WWTP – Effluent Disposal Options Analysis (Outfall vs. Ground) Rev. 2

One or more permits will require consultation with First Nations communities. Early engagement with First Nations is recommended prior to detailed design to verify the outfall is appropriately sited.

Regulatory agencies will also require confirmation the outfall will not significantly affect other stakeholder groups such as commercial operators or public use. In regards to the Bowser area, shellfish resources are an important marine resource, so early engagement of shellfish growers (aquaculture) and harvesters (wild stocks) is recommended. Also, education for the general public about the project and level of treatment will be important to provide confidence that public health and the environment will be adequately protected.

A Stage II Environmental Impact Study (EIS) for the outfall will be needed which involves field sampling of the receiving environment (refer to Section 8.2) and analysis of the collected site data. The Stage II EIS will ultimately have to demonstrate the selected outfall site is appropriate and complies with regulatory requirements.

4.5. COST ESTIMATE

The estimated construction costs for the marine outfall are summarized in Table 4 below. Costs are presented for both a 150 mm (6 inch) and 200 mm (8 inch) pipe diameters for outfall alignment option A (Figure 3). The costs include the foreshore outfall pipeline, and immediate shoreline infrastructure (flush assembly, piping and signage). The estimate does not include costs associated with the conveyance pipeline from the treatment plant to the shoreline. The engineering and permitting costs do not include public or stakeholder consultation.

The costs for outfall construction are based on the installation methods described in the preceding sections. In accordance with the level of engineering design completed, the estimates are considered to be Class C (+/- 30%). The estimates are provided in 2015 Canadian dollars.

Table 4 - Design and Construction Cost Estimate (Option A)

Item	150 mm (6 inch) Outfall	200 mm (8 inch) Outfall
Materials	$141,000	$170,000
Equipment + Labour	$291,000	$336,000
Environmental Remediation	$50,000	$50,000
Engineering and Permitting (15%)	$72,300	$83,400
Contingency (30 %)	$166,290	$191,820
Total Estimate	**$720,590**	**$831,220**

For comparison, the costs associated for outfall alignment Option B are summarized in Table 5 for both pipe diameters. Costs are higher due to the additional overall length of the outfall, longer portion of the outfall in the intertidal and shallow subtidal zones where burial is required, and the proximity of Nile Creek to this option which poses an erosion risk.

Reference: Bowser WWTP – Effluent Disposal Options Analysis (Outfall vs. Ground) Rev. 2

Table 5 - Design and Construction Cost Estimate (Option B)		
Item	**150 mm (6 inch) Outfall**	**200 mm (8 inch) Outfall**
Materials	$200,000	$265,000
Equipment + Labour	$464,000	$519,000
Environmental Remediation	$75,000	$75,000
Engineering and Permitting (15%)	$110,850	$128,850
Contingency (30%)	$254,955	$296,355
Total Estimate	**$1,104,805**	**$1,284,205**

5. CONCLUSIONS

Based on the investigations and conclusions of the geotechnical and marine outfall experts, it is our recommendation that Stantec proceed with Prliminary Design of the wastewater plant based on a marine outfall discharge.

STANTEC CONSULTING LTD.

Prepared by ____
(signature)
Stan Spencer, P.Eng.

Reviewed by ____
(signature)
David Lycon, Ph.D., P.Eng. PE

Appendix A
Preliminary Geotechnical Assessment

Appendix B
Preliminary Design Report – Marine Disposal

Technical Memo 3 Rev 1

To:	Regional District of Nanaimo Gerald St. Pierre, P.Eng.	From:	Boone Barber, RPBio Stantec – Sidney Office
File:	111700522	Date:	March 10, 2016

Reference: **Bowser WWTP – Environmental Studies and Permitting Considerations**

1. INTRODUCTION

1.1. BACKGROUND

As part of the development of the preliminary design for the Bowser Village Centre Wastewater Service Project (the Project), a review of environmental studies and regulatory permitting requirements has been undertaken. This review will provide a summary of the environmental studies and regulatory permitting activities that will be required prior to construction of the proposed work.

2. ENVIRONMENTAL PERMITTING REQUIREMENTS

The subsections below outline the federal and provincial environmental regulatory permits (i.e., approvals, permits, and authorizations) that may be required for a marine based wastewater disposal and associated upland infrastructure (i.e., treatment plant, sanitary forcemain, pump stations). Field surveys and reports that may be required to support the environmental regulatory permits are also described.

2.1. ENVIRONMENTAL STUDIES

Background

Environmental regulatory permits, such as provincial Crown Land Tenure, Section 9 *Water Act* permit applications, *Municipal Wastewater Regulation* Discharge Permit and federal Fisheries and Oceans Canada (DFO) Request for Review typically require site-specific information to supplement the applications. The site-specific information is used to assess the biological and physical habitat characteristics of a site and provide information on biological resources in the area. This information is used by Qualified Professionals to assist in identifying potential environmental impacts that may be associated with the Project and to develop mitigation measures to avoid or mitigate harm to biological, social and cultural resources and habitat.

Field Surveys

Prior to field surveys, desktop information is typically collected to support the development of field surveys, such as description of the physical environment, wildlife, vegetation and aquatic resources, socio-economic uses and cultural and heritage resources in the area. In addition, Project- and community-specific background information is reviewed. Available online government databases, such as DFO Mapster, provincial Coastal Resource Information Management System and British Columbia Species and Ecosystem Explorer are also accessed to assist in identifying biological resources and potential species at risk that may occur in the Project area.

Vegetation, wildlife and aquatic resource assessments may be required for the Project. The scale of assessments is typically dependent on construction footprint, habitat quality, level of vegetation disturbance (i.e., clearing/falling), potential for wildlife within the footprint, presence of commercial, recreational and Aboriginal (CRA) fish species (e.g., shellfish beds) and important aquatic habitats (e.g., eelgrass beds).

Terrestrial surveys for this Project will likely include a vegetation and wildlife survey. Typically a vegetation assessment is required to inventory vegetation resources within and immediately adjacent to the proposed construction footprint. The vegetation field survey typically includes assessing the proposed Project location(s) for any vegetation features of concern (e.g., rare plants, small wetlands, sloughs, riparian habitat, trees over 30 cm in diameter). The location of such vegetation features are recorded and added to the construction drawings. Prior to construction, a wildlife field survey is recommended to inventory important and/or sensitive habitat features such as nesting areas, burrows, dens and/or breeding sites within and immediately adjacent to the proposed construction footprint.

An aquatic field survey is recommended to assess and document CRA fisheries resources and important habitats (e.g., eelgrass, kelp beds, fish-bearing streams, wetlands) that are within or near the Project footprint. The aquatic field survey will likely include both marine and freshwater surveys. The marine habitat survey will include an intertidal and subtidal assessment of portions of the marine project footprint which will include an intertidal and subtidal (by diver) shellfish inventory. Where project biologists are not able to access certain areas of the marine project site (e.g., water depth limitations), best available desktop information, such as online databases and existing literature will be used. It is recommended that Project-specific information from other field investigations, such as geotechnical investigations and outfall routing, be reviewed. It is recommended that the videos from divers and remotely operated vehicles from other Project-related studies be reviewed to assist in supplementing the aquatic field survey data, particularly in subtidal environments. Freshwater habitat surveys are recommended and should include areas that are within the Project footprint, such as sanitary forcemain crossings or riparian vegetation disturbance. These surveys should include, but are not limited to, an assessment of the habitat that may be impacted by construction, such as the channel, substrate, riparian and CRA fisheries.

Timing: Vegetation and wildlife field surveys are typically between May through July when vegetation is fully leafed out, flower plants in bloom and breeding birds are present. Marine aquatic field surveys should be conducted during a low tide during peak eelgrass growing season, typically between May and August.

Cost: The preliminary estimate for a desktop environmental study is $4,000 - $5,000. The preliminary estimated cost for the terrestrial field surveys (vegetation and wildlife) and subsequent reporting are $15,000 - $20,000. This cost does not include construction environmental monitoring, pre-construction bird nest sweeps, hazard tree assessments and construction arborist services. The preliminary cost for the aquatic (freshwater and marine) field surveys and subsequent reporting are $20,000 - $30,000 depending on the Project footprint, biological resources and important habitats encountered during the work. This cost does not include a separate subtidal habitat survey as it is expected that videos from other Project components may be used to describe the habitat. A detailed cost estimate has not been prepared.

2.2. CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN

A Construction Environmental Management Plan (CEMP) is a Project-specific document commonly prepared to outline mitigation measures to mitigate potential environmental effects to terrestrial and aquatic resources and habitats, as well as avoid or mitigate 'serious harm to fish' during project construction.

Information collected during the desktop and field environmental surveys are used in the development of the CEMP, particularly when identifying potential environmental impacts and project components that may cause impacts to the environment. In addition, Project-specific information, such as engineering design, construction materials and methods and Project-timing are used in the development of the CEMP.

The CEMP is a living document that is typically reviewed and updated prior to and during construction by the client, Project biologists, engineers, contractors and regulators. The mitigation measures and monitoring requirements outlined in the CEMP are often re-evaluated during the course of a Project, particularly when teams identify deficiencies and/or improve construction methods or environmental protection measures. The CEMP is meant to be written so that it is easily understood by all onsite contractors and is not meant to be onerous to follow.

The CEMP is used to supplement environmental regulatory permits, such as provincial Crown Land, Section 9 *Water Act* application and the DFO Request for Review. In addition, the CEMP is typically included in the construction tender package for contractors to review during the tender process and used by the contractor and environmental monitor during construction to avoid and mitigate potential environmental impacts associated with project construction activities.

Timing: The CEMP is typically developed after the environmental studies and before the preparation of environmental regulatory permit applications during the detailed design phase of a project.

Cost: The preliminary estimate for CEMP is $8,000-$10,000. A detailed cost estimate has not been prepared.

2.3. PROVINCIAL CROWN LAND TENURE – MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

Project activities on provincial Crown Land (e.g., land, including the intertidal and subtidal seabed areas from the high water mark to the provincial jurisdiction limits) require permission by the Province of British Columbia (Ministry of Forests, Lands and Natural Resource Operations [MFLNRO]). Permission is obtained by application to the Province under the appropriate program area (e.g., utilities program). Utilities on Crown Land are normally authorized by statutory rights-of-way or easements. Information collected during the environmental studies are used in the development of the Crown Land application. Information often included in a Crown Land application is a site plan identifying the tenure area requested, management plan (includes project description, location, consultation, potential environmental and socio-economic impacts), and a land survey. In addition, public advertising and staking is required. The Province is responsible for public consultation.

Reference: Bowser WWTP –

At this time, it is expected that a Crown Land application will be required for the outfall component of the Project and no other Project infrastructure will require an application.

Timing: This permit application can take a minimum 6 months to be reviewed by the Province.

Cost: The preliminary estimated cost to prepare a Crown Land tenure application package and regulatory liaison for a marine outfall is in the range of $6,000 - $8,000. Studies and documents to support this application are budgeted separately in this document (e.g., marine and freshwater habitat studies, CEMP). A detailed cost estimate has not been prepared. Work and fees associated with the permit application, advertising, staking notices and consultation (e.g., public and First Nation) are typically costed separately after MFLNRO has reviewed and provided comment to the initial application.

2.4. NAVIGATION PROTECTION ACT – TRANSPORT CANADA

The *Navigation Protection Act* (NPA) prohibits the construction of certain projects on marine and navigable freshwater without approval from Transport Canada. Projects that affect navigable waters may require approval under the NPA. The Pacific Ocean (including waters up to the higher high water mean tide level) is as a navigable water under the Navigable Waters Schedule. A 'Notice of Works' is required to the Minister when a proponent proposes to construct, place, alter, repair, rebuild, remove, or decommission a work in a waterway on the List of Scheduled Waters (e.g., Pacific Ocean) and is not a designated work listed in the Minor Work Order (MWO). The MWO allows for work to be built if they meet the criteria for the applicable class of works and the specific terms and conditions for construction.

The information required as part of the "Notice of Works" includes, at minimum: completed "Notice of Work" forms; location map; legal site description and work position; plan view drawings with relevant dimensions; profile view drawings with relevant dimensions; project description; construction methodology; and anticipated start and end dates.

For this Project, an information inquiry with a Navigation Protection Program Officer is recommended to confirm that a 'Notice of Works' is required for the outfall component of the Project.

Timing: A NPA application typically takes a minimum of 3 months to be reviewed by Transport Canada.

Cost: The preliminary estimated cost to prepare a Notice of Works application and liaise with a Navigation Protection Program Officer is typically $3,000. A detailed cost estimate has not been prepared.

2.5. REQUEST FOR REVIEW – FISHERIES AND OCEANS CANADA

Projects in or near water with some connectivity to fish, including both freshwater and marine environments, are required to conduct a 'Self-Assessment' to determine if a DFO Request for Review is required for projects in or near water. The 'Self-Assessment' involves using criteria (e.g., types of waterbodies and project activities) developed by DFO to determine if the project requires a Request for Review. The 'Self-Assessment' involves using criteria (e.g., types of waterbodies and project activities) developed by DFO to determine if the project requires a Request for Review. A

Request for Review is conducted to determine if a project can be completed without causing 'serious harm to fish' as defined under the *Fisheries Act* (Section 35(2)). If DFO determines that 'serious harm to fish' could result from a project and cannot be avoided or mitigated, a *Fisheries Act* Authorization (Section 35(2)(b))will be required before work can commence. When 'serious harm to fish' cannot be avoided or mitigated, offsetting measures (i.e., compensation) will be required.

Often, 'serious harm to fish' can be avoided through project planning and design or mitigated, by employing best management practices and working within least risk timing windows during all phases of a project. Fish and fish habitat assessments (i.e., aquatic field surveys described above) are a common way of developing an understanding of site-specific biological and physical characteristics of the project's receiving environment, and they provide pertinent information as a basis for developing mitigation strategies to avoid 'serious harm to fish'.

A marine fish and fish habitat assessment and a CEMP will likely be required and included as supplementary information packaged with the DFO Request for Review. If 'serious harm to fish' cannot be avoided or mitigated, offsetting (i.e., compensation) may be required. It is expected that one Request for Review application will be required for the Project that will include both freshwater and marine Project components.

Timing: DFO does not have any mandated review timelines. Previous experience indicates that DFO's typically takes a minimum of 3 months to review a Request for Review.

Cost: The preliminary estimated cost to prepare a DFO Request for Review application is in the range of $3,000 - $5,000. This cost is for the preparation and submission of a Request for Review application, regulatory liaison, as well as the gathering of documents and information used to supplement the application. A cost of the field studies and CEMP are provided separately in this document. A detailed cost estimate has not been prepared, and this estimate does not include costs associated with any habitat offsetting should the project be deemed to constitute 'serious harm' to fish under the *Fisheries Act.* This cost estimate does not include construction environmental monitoring that may be required.

2.6. SECTION 9 NOTIFICATION – MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

Changes in and about a stream include any modification to the nature of the stream including the land, vegetation, natural environment or flow of water within the stream, or any activity or construction within the stream channel that has or may have an impact on a stream. The Project will likely require work in and about a stream, as infrastructure (e.g., sanitary force mains, pump stations) is being constructed in the vicinity of a minimum of two streams, Thames Creek and Nile Creek.

Section 9 of the BC *Water Act* requires that a person may only make 'changes in and about a stream' under a Notification or Approval in accordance with Part 7 of the *Water Regulation*. A Section 9 application form is required for a Notification or Approval for 'changes in and about a stream'. It is expected that 'changes in and about a stream' associated with this Project will require a Section 9 Notification. Engineering drawings, habitat information, construction methods, maps and a CEMP is typically included with the Section 9 application. If the work requires fish removal or salvage, then a Fish Salvage Permit is required through FrontCounter BC.

A telephone call with Front Counter BC is recommended to confirm the information requirements of the Section 9 Application and to determine the number of applications required (i.e., when there are multiple stream crossings).

Timing: Section 9 Notifications can take up to 45 days to be reviewed. Once a Notification application has been submitted, the MFLNRO has 45 days to provide comment to the applicant. If the applicant has not been contacted by the MFLNRO, work is allowed to proceed provided the work meets applicable regulations (e.g., *Water Act, Water Regulation*) and Best Management Practices Instream Works.

Cost: The preliminary estimated cost to prepare a Section 9 Notification application is in the range of $2,000 - $4,000. This cost is for the preparation and submission of one Section 9 Notification application, regulatory liaison, as well as the gathering of documents and information used to supplement the application. A cost of the field studies and CEMP are provided separately in this document. A detailed cost estimate has not been prepared, and this estimate does not include construction environmental monitoring that may be required.

2.7. MUNICIPAL WASTEWATER REGULATION REGISTRATION – MINISTRY OF ENVIRONMENT

This Project will require a discharge permit subject to the Municipal Wastewater Regulation (MWR) Registration process. An EIS will be required for the treatment plant and discharge as part of the Project; however, the scope of the EIS is determined at the pre-registration meeting. An EIS is required under the MWR in order to apply for a discharge permit. The Stage 1 EIS identifies physical and socio-economic features, property encumbrance and water system issues, hydrogeological and geotechnical limitations, and includes dilution modelling at the outfall. A Stage 2 EIS includes the information in a Stage 1 as well as site specific information which typically involves field studies, such as pre-discharge water quality monitoring, habitat studies, archaeological studies, current studies, bathymetric study, and plume modelling. For planning and budgetary purposes, assume that Stage 1 and Stage 2 EIS studies will be required.

Timing: Preparing registration documents, operating plans, EIS documents and field studies can take approximately one year. The preparation time depends on the type of studies the MOE requires as they may request multiyear studies (e.g., water quality). After the EIS and registration documents have been submitted to the Province it is put in a queue. Our last update from the Province indicated that it is takes approximately 1 to 1.5 years to conduct a review of the project information.

Cost: It is difficult to provide cost estimate at this point, as the pre-registration meeting drives the scope of work related to the registration process. Typical costs for completing the registration process range from $75,000 to $200,000. Cost savings are anticipated, as the information collected as part of the environmental studies will be used in the EIS where applicable. A detailed cost estimate has not been prepared.

2.8. ARCHAEOLOGICAL IMPACT ASSESSMENT AND PERMITS – MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS

Background

Heritage sites and objects on private and Provincial Crown Land in British Columbia that predate 1846 are automatically protected under the *Heritage Conservation Act* (HCA). The Archaeology Branch of the MFLNRO administers the HCA and is responsible for making final decisions concerning the management of archaeological resources in British Columbia.

Portions of the proposed Project are within areas that contain known, and/or have potential to contain previously unidentified, archaeological resources. Provincial records indicate that proposed pump station 1 and the connecting lines running northeast from Gerrod Road are within the recorded boundaries of archaeological site DiSd-16. The site is a shell midden with recovered bone and stone artifacts. Recent archaeological monitoring for a hydro pole installation confirmed the presence of disturbed archaeological deposits associated with DiSd-16 at the Bowser Road/Gerrod Road intersection.

Additionally, a preliminary desktop review indicates that the boundaries of archaeological site DiSd-16 are not well established and there is potential for archaeological deposits associated with DiSd-16 to be encountered outside or the recorded site boundary along Bowser Road south of the Gerrod Road intersection, as well as along Gerrod Road and Park Avenue. Based on the preliminary desktop review, other areas assessed as having high archaeological potential include the locations of proposed pump stations 2, 3, 4 and 5 and the associated connection lines in proximity of the waterfront.

Recommendations

Archaeological Monitoring – DiSd-16

Given the identified conflict between proposed Project infrastructure and known archaeological site DiSd-16 (see Figure 1 below), an HCA permit is required for any ground work within and adjacent to the recorded site boundary. Customarily, permits required to work within a recorded archaeological site boundary are issued under Section 12 of the HCA (site alteration permits) although in some instances the Archaeology Branch may allow such work to proceed under an HCA Section 14 inspection permit. Archaeological work required under the HCA permit is likely to include on-site archaeological monitoring during ground work within the recorded site boundary. Archaeological monitoring work entails visual inspection of exposed subsurface deposits, examination of all encountered archaeological deposits by raking or screening, stratigraphic mapping, analyses of data and artifacts collected, detailed reporting and any other analysis/treatment needed to appropriately address cultural materials, if encountered.

Please note that deposits identified to contain archaeological material may not be removed from the recorded archaeological site boundary, unless approved by the archaeology branch and relevant First Nations groups.

Map removed due to culturally sensitive information.

Please contact project staff at bowserwastewater@rdn.bc.ca or 1-250-390-6560 for more information.

Archaeological Impact Assessment

An Archaeological Impact Assessment (AIA) following the *BC Archaeological Impact Assessment Guidelines* (Archaeology Branch 1998) is recommended for areas assessed as having high archaeological potential. A Heritage Inspection Permit issued by the Archaeology Branch is required under Section 14 of the HCA to conduct an AIA. AIAs are recommended, and sometimes required, where potential impacts to archaeological resources are anticipated. AIAs are designed to:

- Gain a comprehensive understanding of archaeological resources that may be threatened by the proposed development;
- Inventory the archaeological resources in the Project area;
- Assess the significance and integrity of identified archaeological resources in the Project area;
- Assess potential impacts to archaeological resources by the proposed development;
- Provide recommendations regarding the appropriate management of archaeological resources. These commonly involve the following:
    - Project redesign or relocation to avoid archaeological sites, or
    - Completion of a mitigation program.

AIAs are field-based assessments which commonly involve the following tasks:

- Intensive pedestrian survey of the study area;
- Subsurface testing to search for buried archaeological remains, which commonly involves shovel testing, manual auger drilling and/or soil probing but may also involve mechanical excavation and/or auger drilling;
- Assessment of any identified sites, which involves collection of baseline data about the sites, mapping and photography, and delineation of their spatial extent.

AIAs are conducted in consultation with local First Nations groups. Local First Nations are invited to provide field representatives to participate in the AIA fieldwork. Although First Nations involvement is not mandated by the HCA, it is considered to be a best practice by the Archaeology Branch and the BC Association of Professional Archaeologists. Upon completion of the AIA fieldwork, an AIA report must be produced to fulfill permit obligations. AIA reports:

- Describe sites identified (if any) and evaluate their significance;
- Discuss any conflicts identified between proposed development activities and archaeological sites;
- Provide management recommendations which are proposed to alleviate or eliminate these conflicts.

In addition, archaeological inventory site forms would be submitted to the Archaeology Branch for each site recorded or revisited. These site forms are mandatory and comprise a permanent record of the sites that is maintained and updated by the Archaeology Branch.

It is noted that the majority of the Project footprint is within existing road right-of-ways and is likely predominantly covered by impermeable surfaces (e.g. asphalt, hard-packed gravels, etc.). With that understanding, typical AIA methods involving systematic shovel testing prior to development are likely not feasible. Our proposed approach to the AIA is for archaeological monitoring during Project construction ground works within areas evaluated as having high archaeological potential.

Through a preliminary discussion with the Archaeology Branch, it is expected that a single HCA Section 14 inspection permit will be required, under which archaeological monitoring both within the recorded boundaries of archaeological site DiSd-16 and areas evaluated as having high archaeological potential outside of the site boundaries may occur. A one-day visit to the Project area, in advance of permit application is recommended to refine the archaeological potential with the Project area and identify high archaeological potential locations that may be suitable for subsurface testing by hand in advance of construction monitoring. Preliminary testing could provide an understanding of known archaeological constraints, as opposed to potential constraints, and may result in less time required for construction monitoring (i.e., should nothing be identified during preliminary subsurface testing in areas assessed as having high archaeological potential).

Timing: An HCA permit generally takes at least six to eight weeks to obtain after initial submission of the application to the Archaeology Branch. This includes branch processing and mandatory First Nations review. Fieldwork for the AIA and alteration can occur following receipt of the HCA permit.

Cost: The preliminary estimate for a permit application is $2,000. Costs associated with a one-day visit to the Project area for a single archaeologist in advance of permit application are estimated at approximately $1,200. Costs associated with archaeological monitoring (within the recorded boundaries of DiSd-16 and in areas of assessed high archaeological potential) are estimated at approximately $28,000 for a crew comprised of one recognized Field Director, one Junior Archaeologist and one First Nations representative for eight 10-hour field days. Reporting costs are generally directly proportional to the amount of field time and can vary based on the identification of archaeological deposits, their integrity and the amount of cultural return (artifacts and faunal remains recovered). Assuming disturbed archaeological deposits are encountered, no more than one additional archaeological site is identified and low/moderate cultural return (<50 artifacts and <100 faunal remains), costs associated with archaeological reporting are estimated at approximately $12,000.

These costs represent a very rough ballpark estimate based on a preliminary desktop review and general assumptions. A detailed cost estimate has not been prepared and can be provided upon request.

3. SUMMARY OF ENVIRONMENTAL STUDIES AND PERMIT REQUIREMENTS

There is potential for cost savings, as the information collected as part of the environmental studies will be used in the development of the MWR EIS and Registration.

Studies/Permit/Authorization	Estimated Time (weeks)	Maximum Estimated Cost ($)

Reference: Bowser WWTP –

Environmental Studies	---	---
Desktop Study	2	$5,000
Terrestrial Survey & Reporting (Vegetation & Wildlife)	3	$20,000
Aquatic Survey & Reporting (Freshwater & Marine)	3	$30,000
Construction Environmental Management Plan	2	$10,000
Provincial Crown Land Tenure	26	$8,000
Navigation Protection Act – Notice of Work	12	$3,000
DFO Request for Review	12	$5,000
Section 9 Notification	6	$4,000
MWR Field Studies, EIS and Regulatory Review	130	$200,000
Archaeological Services	---	---
Preliminary site visit	1	$1,200
Section 14 HCA Permit Application	8	$2,000
Archaeological Monitoring	2	$28,000
Archaeological Reporting	2	$12,000
Estimated Total Time and Cost to Complete Environmental Studies and Permits	**130**	**$328,200**

STANTEC CONSULTING LTD.

Prepared by ______________________________
Bonne Barber, RPBio

Reviewed by ______________________________
Stan Spencer, P.Eng.

Stantec

Technical Memo 4

To:	Regional District of Nanaimo	From:	Boone Barber and Joanna Preston
	Gerald St. Pierre, P.Eng.		Victoria BC Office
File:	11170052	Date:	May 30, 2016

Reference: Bowser Village Centre Wastewater System–Desktop Environmental Review

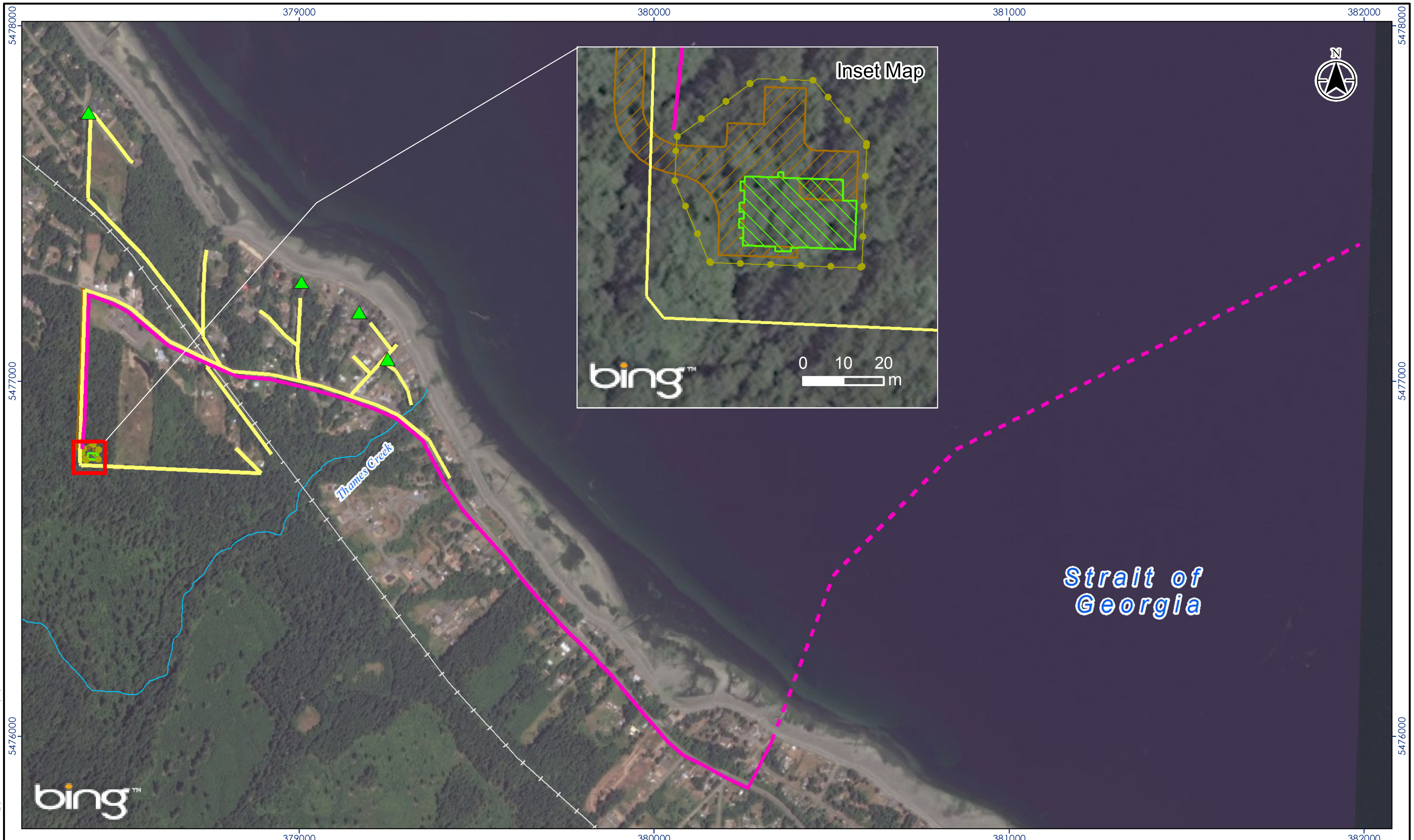
1.0 INTRODUCTION

1.1 BACKGROUND

The Regional District of Nanaimo (RDN) is proposing to install a new community wastewater collection and treatment plant and disposal outfall (the Project) for the Bowser Village Centre (Bowser), British Columbia (BC [Figure 1]). The proposed system will service existing developed properties and provide sufficient capacity to allow for future growth. Several studies have been conducted as part of the Project, including a feasibility study (Chatwin 2011), a preliminary geotechnical assessment (WSP 2016), and effluent disposal options analysis (Stantec 2016a). Based on these studies, a marine effluent disposal design is the preferred option.

1.2 SCOPE OF WORK

Environmental resources are important considerations during preliminary design of a development project. This Technical Memo describes the terrestrial, beach, and freshwater fish bearing components of the Project based on Stantec Consulting Ltd.'s (Stantec) current understanding. The physical marine environment and marine biological resources (including marine birds and mammals) are described in a Stage 1 Environmental Impact Study prepared by GreatPacific Engineering and Environment (2016).



Legend

- Pump Station
- Land Based Outfall *
- Marine Outfall
- Storm Sewer Main
- Fence
- Railway
- Creek
- Wastewater Plant
- Road

* The land based outfall route depicted in this figure is for illustrative purposes only. This route is based on Stantec's current understanding of the project.

0 200 400 metres

1:16,000 (At original document size of 8.5x11)

Notes

1. Coordinate System: NAD 1983 UTM Zone 10N.
2. Base features produced under license with the Province of British Columbia, 2014.
3. British Columbia CanVec 50k Basedata, Bing Imagery.

Regional District of Nanaimo   Stantec

Project Location
Bowser, British Columbia

111700522
Prepared by SP on 2016-05-17
Technical Review by BB on 2016-05-17

Client/Project
Regional District of Nanaimo
Bowser Village Centre Wastewater System

Figure No.
1

Title
Project Location and Infrastructure

S:\1232\projects\111700522\figures\reports\fig_1_111700522_Bowser_Wastewater_System.mxd   Revised: 2016-05-17 By: stparker

2.0 METHODS

Stantec completed a desktop review of terrestrial biological resources (i.e., vegetation and wildlife) and freshwater fish bearing drainages that potentially interact with the Project. The spatial boundary of the desktop review is the preferred option footprint and surrounding area bounded by Deep Bay (north), the coastline (east), Qualicum Bay (south), and 3 km inland (west) (Project area [Figure 2]).

Sources of information used to complete the desktop review included publicly available government and non-government databases and mapping applications (BC Conservation Data Centre; DataBC/iMapBC; NatureCounts; e-fauna; e-flora; EcoCat; RDN MAP; Fisheries and Oceans Canada Mapster; Fisheries Information Summary System), Project-related studies, and professional knowledge of the area. The Canadian Wildlife Service also completed an inventory of sensitive ecosystems for eastern Vancouver Island and Gulf Islands from 1993 to 2004, which included planning and management recommendations by habitat type (McPhee et al. 2000).

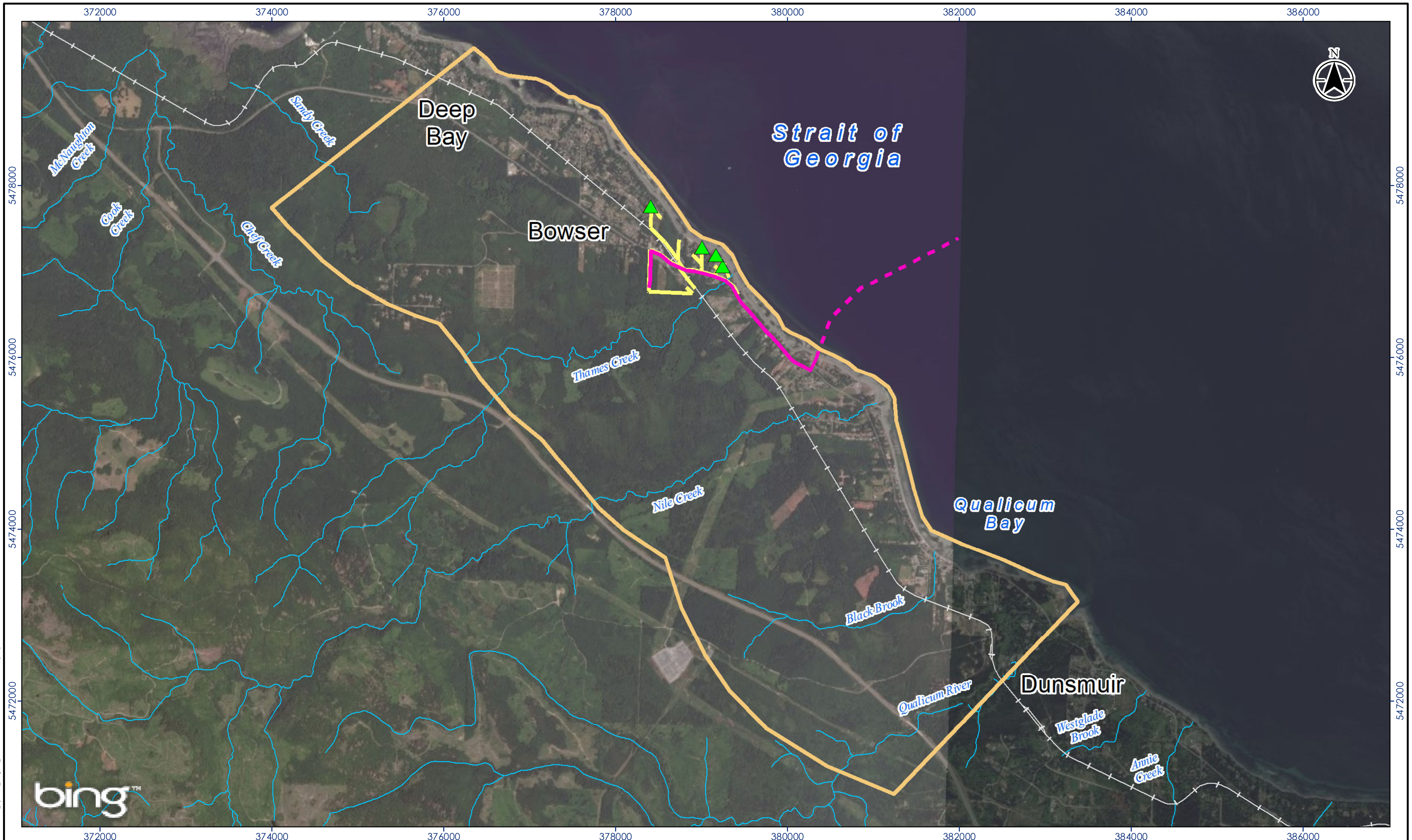
3.0 ENVIRONMENTAL SETTING

3.1 PROJECT LOCATION AND PHYSICAL ENVIRONMENT

The proposed Project is located in the community of Bowser, BC, within the RDN (Figure 1). The Project is located in the Eastern Vancouver Island Ecoregion of the Georgia Depression Ecoprovince. The Project is located in the Coastal Douglas-fir moist maritime (CDFmm) biogeoclimatic subzone. In British Columbia, CDFmm is restricted to the southeast side of Vancouver Island, several gulf islands, and a narrow strip of the adjacent mainland, from sea level to 150 m elevation (Green and Klinka 1994). The CDFmm is characterized as having warm, dry summers, and mild, wet winters.

The proposed collection system and treatment plant location is in the southwest of Bowser, which includes a gravity collection system and four pump stations (one pump station services a strata complex) to pump wastewater to the treatment plant from various low points in the gravity collection system (Figure 1). The proposed catchment areas of the pump stations are provided in Figure 3. The proposed treatment plant location is approximately 500 m from the inland Island Highway along a proposed road, and will be approximately 0.2 ha in size (Figure 1 and Figure 3). Generally, Project infrastructure, such as sanitary forcemains and pump stations are expected to be buried along existing roads and cleared areas. The wastewater treatment plant is proposed to be located in a forested area at the southern end of plan VIP2076 (Crown Lot 1 and 2) within the boundary of Bowser (Figure 1).

Treated wastewater is proposed to be discharged through a marine outfall (via a land-based outfall [Figure 1]), extending from the foreshore at the beach access located along Bovanis Road, aligned with Noonday Road, to approximately 2.3 km into the Strait of Georgia / Salish Sea at a depth of approximately 55 m, relative to chart datum (Figure 1). There is expected to be disturbance to foreshore and beach areas during construction of the marine outfall.



Legend

- Pump Station
- Land Based Outfall *
- Marine Outfall
- Storm Sewer Main
- Railway
- Creek
- Project Area

* The land based outfall route depicted in this figure is for illustrative purposes only. This route is based on Stantec's current understanding of the project.

0 500 1,000 1,500 2,000 metres

1:66,000 (At original document size of 8.5x11)

Notes

1. Coordinate System: NAD 1983 UTM Zone 10N.
2. Base features produced under license with the Province of British Columbia, 2014.
3. British Columbia CanVec 50k Basedata, Bing Imagery.

Regional District of Nanaimo Stantec

Project Location 111700522

Bowser, British Columbia

Prepared by SP on 2016-05-17
Technical Review by BB on 2016-05-17

Client/Project
Regional District of Nanaimo
Bowser Village Centre Wastewater System

Figure No.
2

Title
Project Area

S:\1232\projects\111700522\figures\reports\fig_2_111700522_Bowser_Wastewater_System_Project_Area.mxd Revised: 2016-05-20 By: stparker

Reference: Bowser Village Centre Wastewater System–Desktop Environmental Review

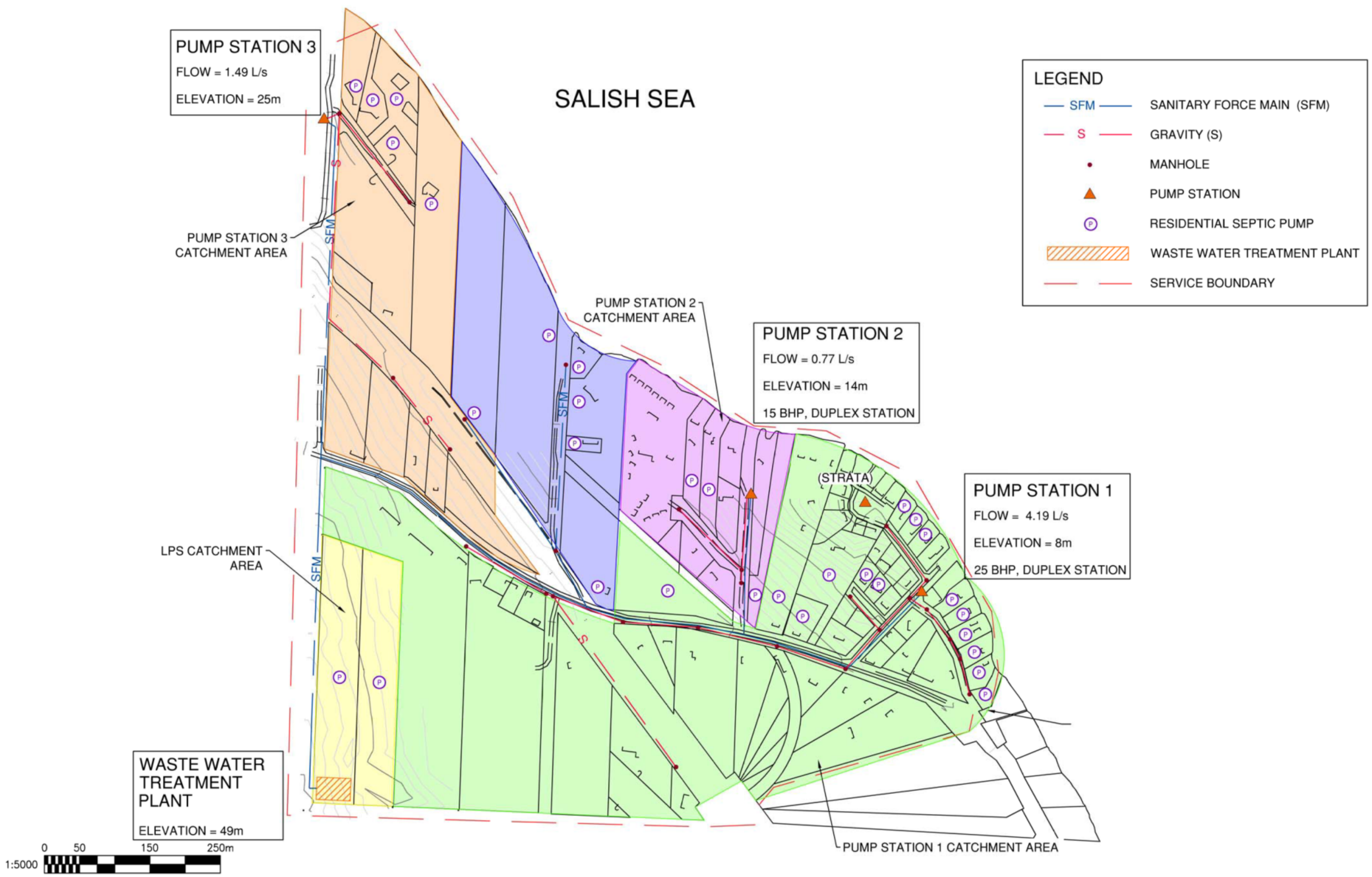


Figure 3 Pump Stations and Catchment Areas

3.2 VEGETATION

The majority of the Project area is developed (urban and rural) or regenerated (second growth) forest. Within the forested habitat, the coastal variety of Douglas-fir (*Pseudotsuga menziesii*) is the most common tree species, and western redcedar (*Thuja plicata*), grand fir (*Abies grandis*), arbutus (*Arbutus menziesii*), Garry oak (*Quercus garryana*), and red alder (*Alnus rubra*) frequently accompany Douglas-fir, depending on site moisture and nutrient regime, and site disturbance history. Based on terrestrial ecosystem mapping completed in 2008 (Madrone 2008), the following site series occur within the Project area:

- Douglas-fir−Salal (CDFmm/01)
- Douglas-fir−Grand fir−Oregon grape (CDFmm/04)
- Western redcedar−Grand fir−Foamflower (CDFmm/06)
- Western redcedar−Indian-plum (CDFmm/13)
- Western redcedar−Slough sedge (CDFmm/14)
- Sitka willow−Pacific willow−Skunk cabbage swamp (CDFmm/Ws51)

The Project will overlap riparian ecosystems and older second growth forest (60–100 years old and >100 years old). Specifically, a polygon 8.3 ha in size along Thames Creek (Figure 1) is identified as a riparian ecosystem corridor with a low level of fragmentation, and a polygon 17.6 ha in size is identified as a an old second growth forest (RDN 2016). Approximately 2.5 km southeast of the proposed treatment plant, the Project intersects the marine environment at the proposed outfall north of the mouth of Nile Creek, which is beachland habitat.

There are 43 ecological communities and 46 plant species of management concern (i.e., provincially red or blue listed, listed as extirpated, endangered, threatened, or special concern on Schedule 1 of the *Species at Risk Act* [SARA]) within CDFmm in the RDN (BC CDC 2016). Most of these are not expected to occur within the Project footprint because of the relatively small size of the footprint and the overlap with existing development. The Project will not interact with rocky outcrops, cliff habitats, dry deciduous forests, Garry oak habitats, or marsh/fen wetlands, which include many ecological communities and plant species of management concern. Therefore, based on the location of the Project within old second growth forest, riparian, and beach habitats, 12 ecological communities and 25 plant species of management concern potentially occur within the Project area (BC CDC 2016; Table 1 and Table 2).

A review of databases confirmed the presence of four red listed ecological communities within the Project area: Grand Fir/Dull Oregon-grape; Douglas-fir/Dull Oregon-grape; Western Redcedar/Vanilla-leaf; and, Red Alder/Slough Sedge [Black Cottonwood] (Table 1). The proposed footprint of the wastewater treatment plant and road overlaps the Bowser Complex Coastal Douglas-fir Conservation Land (Figure 4), which is an old second growth forest established for the protection of the Douglas-fir/Dull Oregon-grape ecological community (Cadrin 2011; RDN 2016). Older second growth forests are important for future older forest, landscape connectivity, and buffers for other sensitive ecosystems (e.g., riparian corridors) (Ward et al. 1998). There are no known occurrence records of plant species of management concern within the Project area.

Reference: Bowser Village Centre Wastewater System–Desktop Environmental Review

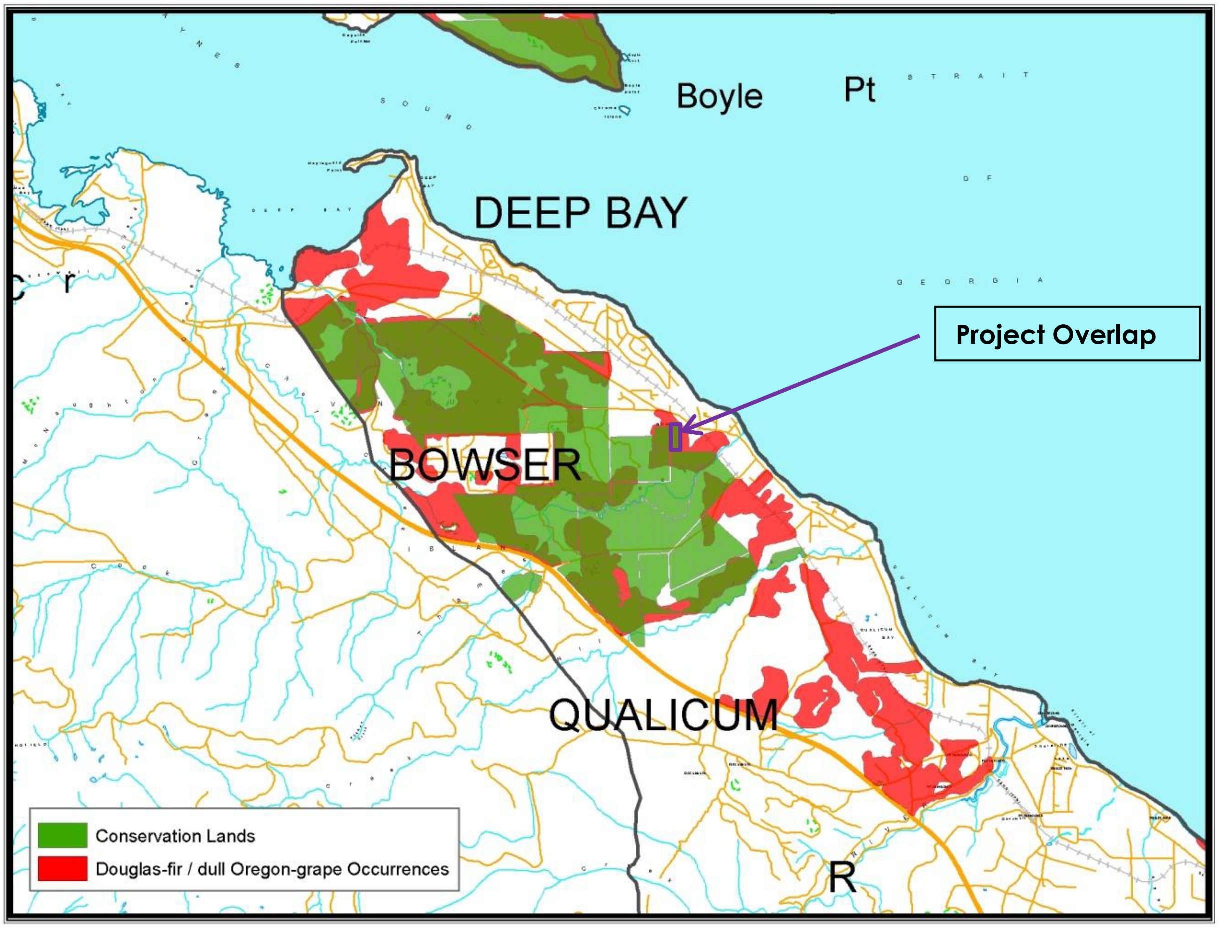


Figure 4 Bowser Complex Douglas-fir Conservation Land Approximate Project Overlap (Purple Box)

Table 1 Ecological Communities of Management Concern that Potentially Occur in the Project Area

Ecological Community	Scientific Name	BC Status	Ecosystem Group	Nearby Known Locations
Northern Wormwood–Red Fescue/Grey Rock-moss	*Artemisia campestris–Festuca rubra/Racomitrium canescens*	Red	Beach: Beachland	None
Large-headed Sedge Herbaceous Vegetation	*Carex macrocephal*	Red	Beach: Beachland	None
Dune Wildrye–Beach Pea	*Leymus mollis ssp. mollis–Lathyrus japonicus*	Red	Beach: Beachland	None
Western Redcedar/Common Snowberry	*Thuja plicata/Symphoricarpos albus*	Red	Flood: Highbench; Forest: Mixed–moist/wet	Qualicum River from mouth upstream for 1 km
Black Cottonwood–Red Alder/Salmonberry	*Populus trichocarpa–Alnus rubra/Rubus spectabilis*	Blue	Flood: Midbench; Forest: Broadleaf–moist/wet	Sandy Creek, Deep Bay; Qualicum River
Grand Fir/Dull Oregon-grape	*Abies grandis/Mahonia nervosa*	Red	Forest: Coniferous–mesic	Bowser
Douglas-fir/Dull Oregon-grape	*Pseudotsuga menziesii/Mahonia nervosa*	Red	Forest: Coniferous–mesic	Bowser; Deep Bay; Qualicum River
Western Redcedar–Douglas-fir/Oregon Beaked-moss	*Thuja plicata–Pseudotsuga menziesii/Eurhynchium oreganum*	Red	Forest: Coniferous–moist/wet	None
Western Redcedar/Vanilla-leaf	*Thuja plicata/Achlys triphylla*	Red	Forest: Coniferous–moist/wet	Bowser
Western Redcedar/Indian-plum	*Thuja plicata/Oemleria cerasiformis*	Red	Forest: Coniferous–moist/wet	None
Tiny Mousetail–Montias–Macoun's Meadow-foam	*Myosurus minimus–Montia spp.–Limnanthes macounii*	Red	Hydrogenic: Vernal Pool	None
Red Alder/Slough Sedge [Black Cottonwood]	*Alnus rubra/Carex obnupta [Populus trichocarpa]*	Red	Mineral: Wetland Swamp	Thames Creek, Bowser

Table 2 Plant Species of Management Concern that Potentially Occur in the Project Area

Species Name	Common Name	BC Status	Conservation Framework Rank	COSEWIC & SARA (Schedule 1)	Habitat Association
Nonvascular–Mosses					
Fissidens ventricosus	N/A	Blue	2	—	Streams
Entosthodon fascicularis	Banded Cord-moss	Blue	2	Special Concern	Sandy soil, open to shady; typically associated with Garry oak ecosystems
Funaria muhlenbergii	N/A	Blue	2	—	Sparsely Vegetated
Racomitrium pacificum	N/A	Blue	2	—	Rocks, stream side and rock outcrops
Platyhypnidium riparioides	N/A	Blue	2	—	Streams, on rocks, wood, tree roots
Crumia latifolia	N/A	Blue	2	—	Rock; Roadside; Wet areas
Syntrichia laevipila	Twisted Oak Moss	Blue	2	Special Concern	Bark of trees, particularly Garry oak, occasionally big-leaf maple
Vascular–Dicots					
Bidens amplissima	Vancouver Island Beggarticks	Blue	1	Special Concern	Estuary; Beach; Mudflats
Packera macounii	Macoun's Groundsel	Blue	2	—	Rock/Sparsely Vegetated; Grassland; Conifer Forest, dry
Sericocarpus rigidus	White-top Aster	Red	1	Special Concern	Rock/Sparsely Vegetated; Meadow; Mixed Forest (deciduous/coniferous mix)
Uropappus lindleyi	Lindley's Microseris/Lindley's False Silverpuff	Red	1	Endangered	Meadow; Deciduous Forest; Conifer Forest, dry
Heterocodon rariflorum	Heterocodon	Blue	2	—	Vernal Pools/Seasonal Seeps; Conifer Forest, mesic; Conifer Forest, moist/wet
Limnanthes macounii	Macoun's Meadow-foam	Red	1	Threatened	Meadow; Deciduous/Broadleaf Forest

Table 2 Plant Species of Management Concern that Potentially Occur in the Project Area

Species Name	Common Name	BC Status	Conservation Framework Rank	COSEWIC & SARA (Schedule 1)	Habitat Association
Anagallis minima	Chaffweed	Blue	2	—	Estuary; Stream/River; Rock/Sparsely Vegetated; Meadow; Beach; Gravel Bar
Ranunculus alismifolius var. alismifolius	Water-plantain Buttercup	Red	1	Endangered	Vernal Pools/Seasonal Seeps; Stream/River; Meadow
Toxicodendron diversilobum	Poison Oak	Blue	2	—	Rock/Sparsely Vegetated; Deciduous Forest; Conifer Forest, dry
Viola howellii	Howell's Violet	Red	2	—	Rock/Sparsely Vegetated; Meadow; Conifer Forest, moist/wet
Viola praemorsa ssp. praemorsa	Yellow Montane Violet	Red	1	Endangered	Pasture/Old Field; Meadow
Vascular–Ferns					
Dryopteris arguta	Coastal Wood Fern	Blue	2	Special Concern	Stream/River; Rock/Sparsely Vegetated; Grassland; Deciduous Forest; Conifer Forest, dry; Mixed Forest (deciduous/coniferous mix)
Vascular–Monocots					
Allium amplectens	Slimleaf Onion	Blue	2	—	Vernal Pools/Seasonal Seeps; Rock/Sparsely Vegetated; Meadow
Allium geyeri var. tenerum	Geyer's Onion	Blue	3	—	Vernal Pools/Seasonal Seeps; Rock/Sparsely Vegetated; Riparian Herbaceous
Triglochin concinna	Graceful Arrow-grass	Blue	3	—	Alkali Ponds/Salt Flats; Riparian Shrub; Riparian Herbaceous; Mudflats
Malaxis brachypoda	White Adder's-mouth Orchid	Blue	3	—	Riparian Forest; Rock/Sparsely Vegetated; Conifer Forest, moist/wet; Mudflats

Reference: Bowser Village Centre Wastewater System–Desktop Environmental Review

Table 2 Plant Species of Management Concern that Potentially Occur in the Project Area

Species Name	Common Name	BC Status	Conservation Framework Rank	COSEWIC & SARA (Schedule 1)	Habitat Association
Vascular–Quillworts					
Isoetes nuttallii	Nuttall's Quillwort	Blue	2	—	Vernal Pools/Seasonal Seeps; Stream/River; Rock/Sparsely Vegetated; Meadow; Conifer Forest, dry
Vascular–Grapeferns					
Botrychium simplex var. compositum	Least Moonwort	Blue	—	—	Vernal Pools/Seasonal Seeps

NOTES:

N/A: not applicable; no name given.

BC Status: BC listing of species established by the Conservation Data Centre; red is endangered or threatened, blue is special concern, yellow is secure; http://a100.gov.bc.ca/pub/eswp/.

Conservation Framework Rank: the conservation priority assigned to each species in BC under the Conservation Framework, from 1 (highest) to 6 (lowest); http://www.env.gov.bc.ca/conservationframework.

COSEWIC: Committee on the Status of Endangered Wildlife in Canada; assessed species status provided on the Wildlife Species Search http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm.

SARA: species' status provided on the Public Registry http://www.sararegistry.gc.ca/default.asp?lang=En&n=24F7211B-1.

3.3 WILDLIFE

Based on the review of species' ranges and habitat associations, there are more than 30 mammals, more than 200 birds, four reptiles, nine amphibians, and numerous invertebrate species that potentially occur in the Project area. Wildlife will likely interact with all components of the Project; however, the interaction for each species will vary depending on the habitat present and season. Native wildlife and the nests of bald eagle (*Haliaeetus leucocephalus*), great blue heron (*Ardea herodias fannini*), osprey (*Pandion haliaetus*), and peregrine falcon (*Falco peregrinus pealei*) are protected in BC under the BC *Wildlife Act*. In addition, most migratory birds are protected under the *Migratory Birds Convention Act*; these include game birds (e.g., waterfowl, rails, and shorebirds), insectivorous species (e.g., flycatchers, warblers, swallows, and all perching birds that feed on insects), and nongame birds (e.g., bitterns, herons, gulls, loons, and grebes).

Table 3 provides a list of species of management concern (i.e., provincially red or blue listed, listed as extirpated, endangered, threatened, or special concern on Schedule 1 of the SARA, identified wildlife, and species for which their nests are protected under the BC *Wildlife Act*) that potentially occur within the Project area, and their status and habitat associations. Species of management concern that potentially occur in old second growth forest habitats within the proposed footprint of the wastewater treatment plant and road include Keen's myotis (*Myotis keenii*), northern goshawk (*Accipiter gentilis laingi*), western screech-owl (*Megascops kennicottii kennicottii*), band-tailed pigeon (*Patagioenas fasciata*), olive-sided flycatcher (*Contopus cooperi*), western toad (*Anaxyrus boreas*), and northern red-legged frog (*Rana aurora*). Species of management concern that potentially occur in streams and riparian habitats intersected by the proposed Project include American water shrew (*Sorex palustris brooksi*), American bittern (*Botaurus lentiginosus*), western toad, and northern red-legged frog. Species of management concern that potentially occur in open habitats along the coastline within the proposed footprint of the pump stations and marine outfall include short-eared owl (*Asio flammeus*), common nighthawk (*Chordeiles minor*), great-blue heron, and barn swallow (*Hirundo rustica*).

A review of data sources confirmed the presence of 10 species of management concern within the Project area: Townsend's big-eared bat (*Corynorhinus townsendii*), bald eagle, band-tailed pigeon, barn swallow, brant (*Branta bernicla*), double-crested cormorant (*Phalacrocorax auritus*), great blue heron, osprey, peregrine falcon, and western toad (NatureCounts 2016; BC CDC 2016; e-fauna 2016).

Reference: Bowser Village Centre Wastewater System–Desktop Environmental Review

Table 3 Wildlife Species of Management Concern that Potentially Occur in the Project Area

Species	Scientific Name	BC Status	Conservation Framework Rank	Identified Wildlife	COSEWIC	SARA (Schedule 1)	Habitat Association
Mammals							
Ermine, Anguinae Subspecies	*Mustela ermine anguinae*	Blue	2	—	—	—	Forest, riparian, fields
Steller Sea Lion	*Eumetopias jubatus*	Blue	2	—	Special Concern	Special Concern	Beach, log booms, marinas
Townsend's Big-eared Bat	*Corynorhinus townsendii*	Blue	2	—	—	—	Forest, riparian, caves
Keen's Myotis	*Myotis keenii*	Blue	1	Yes	Data Deficient	—	Forest, riparian, caves, rock crevices, buildings
Little Brown Myotis	*Myotis lucifugus*	Yellow	5	—	Endangered	Endangered	Forest, riparian, caves, rock crevices, buildings
American Water Shrew, Brooksi Subspecies	*Sorex palustris brooksi*	Red	1	Yes	—	—	Riparian, Cowichan River estuary
Birds							
Brant	*Branta bernicla*	Blue	2	—	—	—	Estuary, beach
Double-crested Cormorant	*Phalacrocorax auritus*	Blue	2	—	Not at Risk	—	Estuary, beach
American Bittern	*Botaurus lentiginosus*	Blue	2	—	—	—	Riparian, creeks, estuary
Great Blue Heron, Fannini Subspecies	*Ardea herodias fannini*	Blue	1	Yes	Special Concern	Special Concern	Riparian, creeks, estuary, beach
Green Heron	*Butorides virescens*	Blue	4	—	—	—	Riparian, creeks, estuary
Osprey	*Pandion haliaetus*	Yellow	6	—	—	—	Riparian, creeks, estuary

Reference: Bowser Village Centre Wastewater System–Desktop Environmental Review

Table 3 Wildlife Species of Management Concern that Potentially Occur in the Project Area

Species	Scientific Name	BC Status	Conservation Framework Rank	Identified Wildlife	COSEWIC	SARA (Schedule 1)	Habitat Association
Bald Eagle	*Haliaeetus leucocephalus*	Yellow	6	—	—	—	Riparian, creeks, estuary
Northern Goshawk, Laingi Subspecies	*Accipiter gentilis laingi*	Red	1	Yes	Threatened	Threatened	Forest, riparian
Band-tailed Pigeon	*Patagioenas fasciata*	Blue	2	—	Special Concern	Special Concern	Forest, riparian, rural
Barn Owl	*Tyto alba*	Red	2	—	Threatened	Special Concern	Fields
Western Screech-owl, Kennicottii Subspecies	*Megascops kennicottii kennicottii*	Blue	1	—	Threatened	Special Concern	Forest
Northern Pygmy-Owl, Swarthi Subspecies	*Glaucidium gnoma swarthi*	Blue	1	Yes	—	—	Forest
Short-eared Owl	*Asio flammeus*	Blue	2	Yes	Special Concern	Special Concern	Fields, estuary
Common Nighthawk	*Chordeiles minor*	Yellow	2	—	Threatened	Threatened	Fields, beach, gravel bar, rock/sparsely vegetated
Black Swift	*Cypseloides niger*	Blue	2	—	Endangered	—	Streams, cliffs
Peregrine Falcon, Pealei Subspecies	*Falco peregrinus pealei*	Blue	1	—	Special Concern	Special Concern	Estuary, cliffs, urban
Olive-sided Flycatcher	*Contopus cooperi*	Blue	2	—	Threatened	Threatened	Forest, riparian
Purple Martin	*Progne subis*	Blue	3	—	—	—	Estuary, beach
Barn Swallow	*Hirundo rustica*	Blue	2	—	Threatened	—	Fields, rural

Reference: Bowser Village Centre Wastewater System–Desktop Environmental Review

Table 3 Wildlife Species of Management Concern that Potentially Occur in the Project Area

Species	Scientific Name	BC Status	Conservation Framework Rank	Identified Wildlife	COSEWIC	SARA (Schedule 1)	Habitat Association
Western Meadowlark Georgia Depression population	*Sturnella neglecta* pop. 1	Red	1	—	—	—	Fields, estuary
Amphibians							
Western Toad	*Anaxyrus boreas*	Blue	2	—	Special Concern	Special Concern	Forest, riparian, creeks, gravel bar
Northern Red-legged Frog	*Rana aurora*	Blue	1	Yes	Special Concern	Special Concern	Forest, riparian, creeks, gravel bar
Wandering Salamander	*Aneides vagrans*	Blue	2	—	Special Concern	—	Forest, riparian, shrub
Invertebrates							
Propertius Duskywing	*Erynnis propertius*	Red	2	—	—	—	Forest (mixed), meadow
Dun Skipper	*Euphyes vestris*	Red	2	—	Threatened	Threatened	Vernal pools/seasonal seeps, meadow
Western Branded Skipper, oregonia subspecies	*Hesperia colorado oregonia*	Red	2	—	Endangered	—	Fields, Forest (deciduous)
Moss' Elfin, Mossii Subspecies	*Callophrys mossii mossii*	Blue	2	—	—	—	Rock/sparsely vegetated, shrub, Forest (deciduous)
Boisduval's Blue, Blackmorei Subspecies	*Plebejus icarioides blackmorei*	Blue	3	—	—	—	Meadow

Table 3 Wildlife Species of Management Concern that Potentially Occur in the Project Area

Species	Scientific Name	BC Status	Conservation Framework Rank	Identified Wildlife	COSEWIC	SARA (Schedule 1)	Habitat Association
Greenish Blue, Insulanus Subspecies	*Plebejus saepiolus insulanus*	Red	1	—	Endangered	Endangered	Riparian, Forest (deciduous), gravel bar, fields
Common Woodnymph, Incana Subspecies	*Cercyonis pegala incana*	Red	2	—	—	—	Fields, Forest (dry coniferous)
Common Ringlet, Insulana Subspecies	*Coenonympha tullia insulana*	Red	1	—	—	—	Forest, field, meadow
Monarch	*Danaus plexippus*	Blue	2	—	Special Concern	Special Concern	Field, rural, urban
Zerene Fritillary, Bremnerii Subspecies	*Speyeria zerene bremnerii*	Red	2	—	—	—	Meadow, forest, urban
Clodius Parnassian, claudianus subspecies	*Parnassius clodius claudianus*	Blue	6	—	—	—	
Large Marble, insulanus subspecies	*Euchloe ausonides insulanus*	Red	2	—	Extirpated	Extirpated	Field, meadow, sand dune
Sinuous Snaketail	*Ophiogomphus occidentis*	Blue	2	—	—	—	Streams
Autumn Meadowhawk	*Sympetrum vicinum*	Blue	4	—	—	—	Riparian, streams, forest (mixed)

Table 3 Wildlife Species of Management Concern that Potentially Occur in the Project Area

Species	Scientific Name	BC Status	Conservation Framework Rank	Identified Wildlife	COSEWIC	SARA (Schedule 1)	Habitat Association

NOTES:

BC Status: BC listing of species established by the Conservation Data Centre; red is endangered or threatened, blue is special concern, yellow is secure; http://a100.gov.bc.ca/pub/eswp/.

Conservation Framework Rank: the conservation priority assigned to each species in BC under the Conservation Framework, from 1 (highest) to 6 (lowest); http://www.env.gov.bc.ca/conservationframework.

Identified Wildlife: under the Identified Wildlife Management Strategy, the BC Ministry of Environment established categories of wildlife which require special management attention to address the impacts of forest and range activities on Crown land; http://www.env.gov.bc.ca/wld/frpa/iwms/.

COSEWIC: Committee on the Status of Endangered Wildlife in Canada; assessed species status provided on the Wildlife Species Search http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm.

SARA: species' status provided on the Public Registry http://www.sararegistry.gc.ca/default.asp?lang=En&n=24F7211B-1.

3.4 FISH BEARING DRAINAGES

The proposed Project infrastructure has the potential to interact with freshwater aquatic resources, such as fish-bearing drainages. Fish-bearing drainages within the vicinity of the Project include Thames Creek (watershed code 920-496500), Wildwood Creek (Bowser Creek [no watershed code obtained]) and Nile Creek (watershed code 920-494300 [Figure 2]. Other unidentified tributaries and overland surface flow, such as ditches, may provide fish habitat and/or water to downstream fish habitat.

Thames Creek has a watershed area of approximately 8.8 km^2, originating in the Beaufort Ranges and flowing northeast into the Strait of Georgia (LGL 2011). Thames Creek mainstem is approximately 8.5 km in length with gradients from 0.7–36%. The mean gradient in the lower 6.8 km of Thames Creek is approximately 3.7% (LGL 2011). A review of the provincial Fisheries Information Summary System (FISS) has recorded coho salmon (*Oncorhynchus kisutch*), resident and anadromous cutthroat trout (*O. clarkii*) and steelhead (*O. mykiss*) as being present in Thames Creek (FISS 2016a). The proposed sanitary forcemain has the potential to interact with Thames Creek.

Wildwood Creek drains northeast along McColl Road through Wildwood Community Park into the Strait of Georgia (RDN 2016). Wilwood Creek has been identified as supporting cutthroat trout and potentially coho salmon (Pers. comm. Newman 2016).

Nile Creek has a watershed area of approximately 16.9 km^2 (Braybrook *et al.* 1995), draining northeast from Mount Mark. FISS has recorded pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), coho salmon, resident and anadromous cutthroat trout, rainbow trout (*O. mykiss*) and steelhead as being present in Nile Creek (FISS 2016b). Dolly Varden (*Salvelinus malma*) have also been recorded in Nile Creek (NCES 2016). The upper limit of anadromous fish access is approximately 5.6 km from the mouth of Nile Creek at a waterfall. The marine outfall is proposed to be located in the vicinity of the Nile Creek estuary.

Other fish bearing drainages within the Project area include but are not limited to, Black Brook (watershed code 920-500783), Nash Creek (no watershed code obtained), Qualicum River (watershed code 920-490700), Westglade Brook (no watershed code obtained) and Annie Creek (watershed code 920-488600).

3.5 SPECIES AT RISK

Species at risk on Schedule 1 of SARA that potentially occur within the Project area include nine plants, two mammals, nine birds, two amphibians, and four invertebrates (Table 2 and Table 3) Federal recovery strategies are developed for five of these species:

- Recovery Strategy for the Lindley's False Silverpuffs (*Uropappus lindleyi*) in Canada (Parks Canada Agency 2013)
- Recovery Strategy for Olive-sided Flycatcher (*Contopus cooperi*) in Canada (EC 2016a)
- Recovery Strategy for the Common Nighthawk (*Chordeiles minor*) in Canada (EC 2016b)
- Recovery Strategy for the Island Blue (*Plebejus saepiolus insulanus*) in Canada (Parks Canada Agency 2008)

- Recovery Strategy for Little Brown Myotis (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*), and Tri-colored Bat (*Perimyotis subflavus*) in Canada [proposed] (EC 2015)

Recovery strategies identify primary threats and management actions for the recovery of species at risk. Critical habitat has not yet been identified for these species.

Management plans are developed for two species at risk:

- Management Plan for the Band-tailed Pigeon (*Patagioenas fasciata*) in Canada [proposed] (ECCC 2016a)
- Management Plan for the Short-eared Owl (*Asio flammeus*) in Canada [proposed] (ECCC 2016b)

4.0 POTENTIAL ENVIRONMENTAL CONSTRAINTS OF THE PROJECT

The proposed Project is expected to cross sensitive habitats, such as Thames Creek, Wildwood Creek and the vicinity of the Nile Creek estuary. In addition, the wastewater treatment plant is proposed to be located within the Bowser Complex Coastal Douglas Fir Conservation Land.

Environmental field studies are recommended to provide an understanding of the valued ecosystem components that may be affected by the construction and operation of the Project. These studies include, but are not limited to, vegetation, wildlife, and aquatic surveys. Field surveys are typically scheduled to occur at specific times of the year (e.g., when vegetation is fully leafed out, flower plants are in bloom, breeding birds are present). These field studies typically provide supplemental information to regulatory permit applications and the development of the environmental management plan.

The potential environmental constraints of the Project are:

- Overlap with the Bowser Complex Coastal Douglas-fir Conservation Land
- Potential rare plant occurrences within the Project footprint
- Potential and known wildlife habitat features within and adjacent to the Project footprint
  - Nests of bald eagle, osprey, great blue heron
  - Bat maternity roost sites and hibernacula
  - Western toad and red-legged frog breeding sites
- Wildlife restricted activity periods (i.e., breeding bird nesting periods, disturbance to animals occupying habitat features, amphibian breeding and dispersing periods)
- Potential Project interaction with amphibian dispersal routes
- Potential Project interaction with known and unknown fish-bearing drainages
- Regional timing windows of least risk to fish and fish habitat

These constraints may be avoided through relocation of infrastructure, scheduling construction activities outside of sensitive periods, and following applicable provincial and federal guidelines. Prior to construction, a Project-specific environmental management plan should be developed to outline measures to be employed to avoid or mitigate effects to the environment during construction. The environmental management plan may include pre-construction surveys to identify the need for site specific mitigation.

Surveys may include a rare plant survey, wildlife habitat feature surveys, bird nest surveys, amphibian surveys. Additionally, aquatic resource site isolation and fish relocation may be required. Mitigation measures will follow provincial guidance and associated best management practices (e.g., Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in BC [BC MOE 2016], Ministry of Environment Regional Timing Windows), and federal guidance related to managing incidental take of migratory birds (ECCC 2016c).

Environmental regulatory permits may be necessary as part of the Project. Stantec (2016b) has provided a summary of the environmental regulatory permits that are likely to be needed as part of the Project. In addition to development-related permits, permits will be required if an aerial survey to locate raptor nests is required, and if amphibian and/or fish salvage and relocation are required. Approved permits may include a requirement for additional mitigation and timing constraints.

Additionally, construction may be limited to certain time periods if Project components are in the vicinity of valued ecosystem components, or are taking place within periods of higher sensitivity for certain species. Restricted activity periods are related to instream work, migratory birds and raptor nesting periods, bat roost and hibernation periods, and amphibian breeding and dispersal periods.

5.0 CLOSURE

Please contact the undersigned if you have any questions.

STANTEC CONSULTING LTD.

Prepared by ______________________
(signature)

Boone Barber, R.P.Bio.
Phone: (250) 389-2351

Prepared by ______________________
(signature)

Joanna Preston, R.P.Bio.
Phone: (250) 655-2283

Reviewed by ______________________
(signature)

Kara Hewgill, B.Sc., Senior Associate
Phone: (250) 389-2330

6.0 REFERENCES

Braybrook, C., Bryden, G., and A. Dambergs. 1995. Nile Creek to Trent River. Water Allocation Plan. Ministry of Environment, Lands and Parks. Vancouver Island Region. Available online at: http://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-planning/water_allocation_nile.pdf

British Columbia Conservation Data Centre (BC CDC). 2016. BC Species and Ecosystems Explorer. BC Ministry of Environment, Victoria, BC. Available at: http://a100.gov.bc.ca/pub/eswp/. Accessed April 21, 2016.

British Columbia Ministry of Environment (BC MOE). 2016. Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia. Available at: http://www.env.gov.bc.ca/wld/BMP/bmpintro.html#second . Accessed April 26, 2016.

Cadrin, C. 2011. Ecosystem Conservation of the Coastal Douglas-fir Zone. BC Conservation Data Centre, Presentation at the BC Parks Research Forum, December 6, 2011, Victoria, BC.

Chatwin Engineering Ltd. (Chatwin). 2011. Bowser Sewage Feasibility Study.

Demarchi, D.A. 2011. The British Columbia Ecoregion Classification. Available online at: http://www.env.gov.bc.ca/ecology/ecoregions/

e-Fauna. 2016. Electronic Atlas of the Wildlife of British Columbia. Available at: http://ibis.geog.ubc.ca/biodiversity/efauna/index.shtml. Accessed April 26, 2016.

e-Flora. 2016. Electronic Atlas of the Flora of British Columbia. Available at: http://ibis.geog.ubc.ca/biodiversity/eflora/. Accessed April 26, 2016.

Environment Canada. 2015. Recovery Strategy for Little Brown Myotis (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*), and Tri-colored Bat (*Perimyotis subflavus*) in Canada [Proposed]. *Species at Risk Act* Recovery Strategy Series. Environment Canada, Ottawa. ix + 110 pp.

Environment Canada. 2016a. Recovery Strategy for the Common Nighthawk (*Chordeiles minor*) in Canada. *Species at Risk Act* Recovery Strategy Series. Environment Canada, Ottawa. vii + 49 pp.

Environment Canada. 2016b. Recovery Strategy for the Olive-sided Flycatcher (*Contopus cooperi*) in Canada. *Species at Risk Act* Recovery Strategy Series. Environment Canada, Ottawa. vii + 52 pp.

Environment and Climate Change Canada (ECCC). 2016a. Management Plan for the Band-tailed Pigeon (*Patagioenas fasciata*) in Canada [Proposed]. Species at Risk Act Management Plan Series. Environment Canada, Ottawa. iii + 14 pp.

Environment and Climate Change Canada (ECCC). 2016b. Management Plan for the Short-eared Owl (*Asio flammeus*) in Canada [Proposed]. Species at Risk Act Management Plan Series. Environment Canada, Ottawa. v + 35 pp.

Environment and Climate Change Canada (ECCC). 2016c. Avoidance of Detrimental Effects to Migratory Birds (Incidental Take). Available at: http://www.ec.gc.ca/paom-itmb/. Accessed April 26, 2016.

Fisheries Information Summary System (FISS). 2016a. Fish Inventories Data Queries: Single Waterbody Query: Thames Creek. Watershed Code: 920-496500. Available online at: http://a100.gov.bc.ca/pub/fidq/welcome.do

Fisheries Information Summary System (FISS). 2016b. Fish Inventories Data Queries: Single Waterbody Query: Nile Creek. Watershed Code: 920-494300. Available online at: http://a100.gov.bc.ca/pub/fidq/welcome.do

GreatPacific Engineering and Environment. 2016. Bowser Village Centre Wastewater Service – Collection, Treatment and Disposal. Stage 1 Environmental Impact Study – Marine Disposal. 1018-002.

Green, R.N. and K. Klinka. 1994. A Field Guide for Site Identification and Interpretation for the Vancouver Forest Region. Land Management Handbook Number 28. ISSN 0229-1622. Province of British Columbia. Ministry of Forests.

LGL Limited (LGL). 2011. Protection and Restoration Strategy and Action Plan for Thames and Nash Creeks (Draft). Prepared for Trout Unlimited Canada. Available online at: http://www.rdn.bc.ca/dms/documents/dwwp-reports/big-qualicum-water-region/thames_and_nash_creeks_restoration_and_protection_strategy.pdf

LGL Limited (LGL). 2014. Nile Creek-Qualicum Bay Restoration and Enhancement Program. Habitat Assessment and Rehabilitation Opportunities: Annie and Black Brook Creeks TUC Technical Report BC-002.

Madrone Environmental Services Ltd. (Madrone). 2008. Terrestrial ecosystem mapping of the coastal Douglas-fir biogeoclimatic zone. Available at: http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=15273. Accessed April 26, 2016.

McPhee, M. P. Ward, J. Kirkby, L. Wolfe, N. Page, K. Dunster, N.K. Dawe, and I. Nykwist. 2000. Sensitive Ecosystems Inventory: East Vancouver Island and Gulf Islands 1993-1997. Volume 2: Conservation Manual. Technical Report Series No. 345, Canadian Wildlife Service, Pacific and Yukon Region, BC. Available at: http://www.env.gov.bc.ca/sei/van_gulf/publications.html. Accessed April 25, 2016.

NatureCounts. 2016. Available at: http://www.bsc-eoc.org/birdmon/default/searchquery.jsp?what=download. Accessed April 24, 2016.

Reference: Bowser Village Centre Wastewater System–Desktop Environmental Review

Nile Creek Enhancement Society (NCES). 2016. Nile Creek – Qualicum Bay Watershed Renewal Program. Available online at: http://nilecreek.org/watershed-renewal-program

Parks Canada Agency. 2008. Recovery Strategy for the Island Blue (*Plebejus saepiolus insulanus*) in Canada. Species at Risk Act Recovery Strategy Series. Parks Canada Agency. Ottawa. 8 + 22 pp

Parks Canada Agency. 2013. Recovery Strategy for the Lindley's False Silverpuffs (*Uropappus lindleyi*) in Canada. *Species at Risk Act* Recovery Strategy Series. Parks Canada Agency, Ottawa. vi + 29 pp.

Regional District of Nanaimo (RDN). 2016. GIS/Mapping. Environmental Atlas. Available online at: http://www.rdn.bc.ca/cms.asp?wpID=264

Stantec Consulting Ltd. (Stantec). 2016a. Technical Memo 2. Bowser WWTP – Effluent Disposal Options Analysis (Outfall vs. Ground). Project Number: 111700522

Stantec Consulting Ltd. (Stantec). 2016b. Technical Memo 3. Bowser WWTP – Environmental Studies and Permitting Considerations. Project Number: 111700522

Ward, P., G. Radcliffe, J. Kirkby, J. Illingworth, and C. Cadrin. 1998. Sensitive Ecosystems Inventories: East Vancouver Island and Gulf Islands 1993-1997. Volume 1: Methodology, Ecological Descriptions and Results. Technical Report Series No. 320, Canadian Wildlife Service, Pacific and Yukon Region, BC. Available at: http://www.env.gov.bc.ca/sei/van_gulf/publications.html. Accessed April 25, 2016.

WSP Canada Inc. (WSP). 2016. Bowser Village Centre – Wastewater Service. Preliminary Geotechnical Assessment.

Personal Communication

Jack Newman, Fisheries and Oceans Canada Fish Hatchery Technician. Telephone call April 20, 2016.