Comox Valley
REGIONAL DISTRICT

COMOX VALLEY
WATER TREATMENT PROJECT

OPUS

Schedule B.1

Comox Valley Water Treatment Project

Indicative Design Report

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Executive Summary

Project Overview

The Comox Valley Regional District (CVRD) commissioned the Project to respond to Vancouver Island Health Authority's (VIHA) requirement to provide filtration as part of their water treatment system to comply with Drinking Water Protection Act. The project consists of a new water supply with an initial capacity of 80 ML/day expandable to 120 ML/day. It includes the following proposed elements: a new intake at Comox Lake, a new raw water pump station, a new water treatment plant, conveyance pipelines with connections to the existing system, and ancillary systems and facilities. The size of the

Report Overview

This report presents the further development of the Water Treatment Project (the Project) since the completion of the Project Definition Report (PDR) completed in August 12, 2016 (Opus, 2016). Since the PDR, the following new requirements have been identified by the CVRD which are now reflected in this Indicative Design Report:

- **Project Implementation** – The project is now being delivered under a design-build (DB) model, where all project elements are bundled into a single delivery contract.
- **Treatment Technology** – The PDR selected direct filtration with UV disinfection as the preferred technology. In consideration of the decision to deliver the project as DB, the project now includes membrane filtration, as both submerged and pressure configurations, as allowable technologies in addition to direct filtration.
- **Water Operations** – Recommendations from a facility needs report (RDH Building Science, 2017) for the CVRD Water Department to develop a central facility for offices, material storage, and equipment used for the water distribution system have been incorporated with this project. Therefore, the space requirement of approximately 470 square metres in that report is now incorporated with the building space for the water treatment plant building.

This report incorporates those changes as well as other design refinements related to new data from environmental reviews, geotechnical investigations, and detailed topographic surveys completed this year.

Additional Investigations

Additional work to advance the project detail includes the following:

- **Geotechnical Investigations** – Additional detailed field investigations were performed by Golder Associates at the Raw Water Pump Station site and along the marine pipeline alignment which include hydrographic survey of the lake bed. EXP performed field exploration at the Water Treatment Plant (WTP) site and along the conveyance pipeline alignments. Soil data for the sites is available for design and construction decisions.
- **Environmental Investigations** – Current Environmental completed a detailed environmental assessment and prepared a Project Description for submission to the BC Environmental Assessment Office. These investigations summarize the riparian areas along the lake, stream crossings, and management plans for in-lake construction.
- **Topographic Surveys** – Detailed topographic surveys were completed for the pipeline alignments and for the facility sites.
- **Risk Analysis** - A detailed risk register and risk allocation review was conducted to identify and manage risks.

Report Organization

The report is organized by general project requirements and discipline requirements. These requirements summarize the overall project and will be the basis for developing the Detailed Statement of Requirements which in turn will define the contractual requirements for the DB Proponents.

IDR – Report Content Description

Report Section	Description
Section 1 – Project Background	Summary of the project background and history of the Comox Valley water supply leading to this project.
Section 2 – General Requirements	Description of the general requirements for the project, scope, and terminology used.
Section 3 – Licensing and Permitting	Summary of the licenses and permits related to all aspects of the capital works.
Section 4 – Raw Water Submerged Intake Requirements	Summary of the indicative general requirements for the Raw Water Submerged Intake.
Section 5 – Raw Water Intake Pipeline	Summary of the indicative general requirements for the Raw Water Intake Pipeline.
Section 6 – Raw Water Pump Station	Summary of the indicative general requirements for the Raw Water Pump Station.
Section 7 – Water Treatment Plant	Summary of the indicative general requirements for the Water Treatment Plant.
Section 8 – Civil Design	Summary of the indicative general requirements for the Civil Design elements for this Project.
Section 9 – Land Conveyance Piping	Summary of the indicative general requirements for the Land Conveyance Piping.
Section 10 – Structural Design	Summary of the indicative general requirements for the Structural Design for the RWPS and WTP.
Section 11 – Architectural Design	Summary of the indicative general requirements for the Architectural Design for the RWPS and WTP.
Section 12 – Process Mechanical	Summary of the indicative general requirements for the Process Mechanical elements for this Project.
Section 13 – Building Mechanical	Summary of the indicative general requirements for the Building Mechanical elements for this Project.
Section 14 – Electrical	Summary of the indicative general requirements for the Electrical elements for this Project.
Section 15 – Instrumentation and Controls	Summary of the indicative general requirements for the Instrumentation and Controls required for this Project.
Section 16 – Commissioning	Summary of the indicative Commissioning general requirements for the Project.
Section 17 – Security	Summary of the indicative general requirements for Security at the WTP and RWPS Facility
Section 18 – Project Cost	Summary of the overall project costs.

The geotechnical investigations and environmental reviews are included as appendices to this report.

1. Introduction and Project Background

1.1 Overview

This Indicative Design Report (IDR) defines the elements of work under the Comox Valley Regional District's (CVRD) Comox Valley Water Treatment Project (CVWTP or Project) and presents basic design criteria, approach to the work, and characterization of the project improvements. This section of the report presents background information on the Project and general Project details.

1.2 Project Description

The regulatory authority, Vancouver Island Health Authority (VIHA), requires the CVRD to upgrade their Comox Lake water treatment system to comply with the Drinking Water Protection Act. This decision follows elevated turbidity events in 2014 and 2015, which prompted the CVRD to issue Boil Water Notices for a period of 10 days and 47 days under the direction of VIHA.

The CVRD had obtained a filtration deferral. This approach included an upgrade to their treatment system with ultraviolet (UV) disinfection for the minimum disinfection required on a surface water. However, the Boil Water Notice events experienced in 2014 through into 2015 caused VIHA to revoke the filtration deferral process. VIHA has now directed CVRD to include filtration in their water treatment.

The Project will be administered by the CVRD under a design-build (DB) delivery approach with single point of responsibility to reduce risks and project costs. Opus International Consultants Ltd (Opus) is acting as the Owner's Engineer.

1.3 Naming Conventions

The following naming conventions are used in this report and this project.

Table 1-1: Project Naming Conventions

Infrastructure	Components
Water Treatment Plant (WTP)	
Operations Building	Office and administration space for water treatment staff and for water works staff including public space.
Filtration Complex	Tanks, chemical area, and piping galleries, and electrical rooms for the flocculation and filtration process.
Residuals Treatment Building	Tanks and equipment space for the thickening and dewatering of treatment residuals.
Clearwell	Storage of treated water and attached building for valves, piping, and equipment.
Backwash Equalization	Tank and attached pump station building.
Backwash Treatment	Process tanks and treatment equipment for the treatment of equalized backwash water.
Raw Water Intake	
Intake Screens	Submerged screens within the lake.
Lagoon	Shallow water body between the pump station site and Comox Lake separated by a spit.
Marine Pipeline	Submerged or buried pipeline between the intake screens and the raw water pump station wet-well.
Raw Water Pump Station (RWPS)	Pump Station Building
Conveyance Piping	Raw Water Pipeline Treated Water Pipeline

1.4 Abbreviations and Acronyms

The following abbreviations and acronyms are used in this report:

ACU	actual colour units
AO	aesthetic objective
AOA	Archeological Overview Assessment
ASTM	American Society for Testing and Materials
AWWA	America Water Works Association
BC	British Columbia
BCH	BC Hydro
$CaCO_3$	calcium carbonate
CCTV	closed-circuit television
CT	concentration - contact time
CVRD	Comox Valley Regional District
CVWS	Comox Valley Water System
CVWTP	Comox Valley Water Treatment Project
DB	Design-Build
DFO	Department of Fisheries and Oceans
DOC	dissolved organic carbon
DSOR	Design Statement of Requirements
EA	Environmental Assessment
EAA	Environmental Assessment Act
EAO	Environmental Assessment Office
EMP	Environmental management plan
FGC	Fish and Game Club
GCDWQ	Health Canada's *Guidelines for Canadian Drinking Water Quality*
ha	hectares
HFM	Hancock Forestry Management
HDPE	High Density Polyethylene
HGL	hydraulic grade line
hp	horsepower
HRT	hydraulic retention time
IDR	Indicative Design Report
kW	kilowatt
km	kilometres
kPa	kilopascals
kV	kilovolts
LPHO	low pressure high output
LT2	USEPA's Long Term 2 Enhanced Surface Water Treatment Rule
L	litre
L/s	litres per second
m	metres
m^2	squared meters
m^3	cubic metres
m^3/sec	cubic metres per second
MAC	maximum acceptable concentration
MDD	maximum daily demand
MFLNRO	Ministry of Forests, Lands, and Natural Resource Operations
mg/L	milligram per litre
ML	megalitres

- ML/day megalitres per day
- MLD megalitres per day
- mm millimetres
- MMCD Master Municipal Construction Documents Association
- MOE BC Ministry of Environment
- MOTI BC Ministry of Transportation and Infrastructure
- MP medium pressure
- MPa mega pascals
- MW megawatt
- NTU nephelometric turbidity units
- OMC operation and maintenance centre
- OSHG on-site hypochlorite generation
- PS pump station
- psi pounds per square inch
- PWM Pulse Width Modulation
- RFP Request for proposal
- RFQ Request for quotation
- RWPS raw water pump station
- ROW Right of way
- SROW statutory right of way
- TCU total coliform units
- TM technical memorandum
- TOC total organic carbon
- USEPA United State Environmental Protection Agency
- UV ultraviolet
- V volts
- VIHA Vancouver Island Health Authority
- WTP water treatment plant
- WUP BC Hydro Puntledge River Water Use Plan

2. General Project Requirements

2.1 Overview

This section provides the primary design criteria or references to the relevant reports that previously defined the requirements.

2.2 Raw Water Quality

Water quality is summarized in TM-1 of the PDR. Additional information is in Section 7 of this report.

2.3 Hydraulic Design Criteria

The Hydraulic Design Criteria for each component of the Project is summarized in Table 2.1.

Table 2-1: Hydraulic Design Criteria

COMPONENT	INITIAL	FUTURE	ULTIMATE
Design Year Horizon	20	50	100
Deep Lake Intake			
Capacity (Raw Water), ML/day	143	143	143
Raw Water Pump Station			
Wet well, ML/day	143	143	143
No. of Pumps	3	4	5
Installed Capacity, ML/day	76.5	91.8	122.4
Electrical Capacity (sized for), ML/day	143	143	143
Raw Water Pipeline			
Internal Pipe Diameter (mm)		914 to 1067	
Capacity, ML/day	76.5	91.8	122.4
Velocity, m/s	0.95 to 1.35	1.19 to 1.62	1.59 to 2.16
Water Treatment Plant			
Capacity (Treated Water), ML/day	75	90	120
Direct Filtration			
No. of Flocculation trains	3	4	4
No. of Filters	6	8	8
Net Recovery, w/ backwash treatment,		98	
Pressurized Membrane Filtration			
No. of Trains	6 and 3	9 and 4	9 and 4
Submerged Membrane Filtration			
No. of Trains - Stage 1 and Stage 2	5 and 3	8 and 4	8 and 4
Net Recovery. percent		99	
Treated Water Pipeline			
Internal Pipe Diameter (mm)	1066	1066	1066
Capacity, ML/day	75	90	140
Velocity (m/s) @ WTP Capacity	0.97	1.17	1.56

Changes in the flow rate design criteria between the Project Definition Report and this IDR resulted from the following studies and design reviews.

a. TM-5 was issued following the Project Definition Report which re-visited the flow rate projections in consideration of the continued downward trend in water consumption. Ultimate maximum day demand was revised from 140 ML/day to 120 ML/day.
b. In the future, it could be possible for Cumberland and Royston communities to use the water supplied from this project and those demands are not reflected in the consumption trends. Therefore, while the reduction in the project design flow is justified, the uncertainty about the system service area was motivation to retain the higher 140 ML/day capacity for in lake and raw water pump station structure since the incremental capital cost is much lower now compared to future expansion.
c. If expansion beyond the 120 ML/day is necessary for the other project components, that can be achieved through twinning of pipelines and either re-rating or expansion of the treatment works.

2.4 In-Lake Geotechnical and Geophysical Investigations

Golder Associates performed hydrographic survey and geophysical investigations along the marine pipeline alignment within the lake. Within the vicinity of the lagoon, multiple bore holes were advanced – two along the spit and two at the boat launch area. Bedrock was encountered in the boat launch area but not along the spit. Figure 2-1 shows the locations for bore holes.

Figure 2-1 Geotechnical Work at Raw Water Intake

Additional bore holes are planned within the lagoon and one additional bore hole at the far end of the spit.

2.5 Building Geotechnical Investigations

2.5.1 Water Treatment Plant

One sonic type bore hole was advanced in 2017 to a depth of 14 metres as well as two test pits at the WTP site. Bedrock was not encountered. The soils are a mix of compact to dense sand and silt with some gravel underlain by hard silt. Percolation rates are favorable. Groundwater was not encountered. The geotechnical report is presented in Appendix B (EXP, 2017)

2.5.2 Raw Water Pump Station

One additional bore hole was advanced in 2017 in addition to the bore hole advance in the previous geotechnical work. Bedrock was encountered just below the proposed bottom of the pump station wet-well elevation. Details of the findings are presented in Appendix A (Golder, 2017).

2.6 Survey

The scope of the topographic and hydrographic surveys for the Project included a hydrographic survey of 1 kilometer of proposed marine pipeline, 5 kilometers of pipeline corridor and 2 site surveys.

2.6.1 Bathometric Survey

Hydrographic survey was carried out along the proposed 1 km of piping in Comox Lake, at a 60 m swath with a maximum grid/profile spacing of 10 m.

2.6.2 Land Based Site Survey

Topographic survey was carried out along the proposed pipe alignment, at a 20 m swath with a maximum cross-section spacing of 10 m. The three facility sites: Raw Water Pump Station, Water Treatment Plant and existing chlorination building were surveyed with a maximum grid spacing of 5 m. Control points were set along the proposed alignment at roughly 120 m increments in preparation for future construction phase. The land base survey outputs are as follows:

a. Legal pins have been located to aid in final digital base plan preparations
b. Contour/base plans showing all survey data features, including GIS information and utility information.
c. All significant features along the route (i.e., roads, signs, poles, trees, break lines), including major crossings (i.e. roads, creeks) identified.

2.7 Safety by Design

The Project design approach is to prevent occupational injuries for the life of the project. The prevention through design approach will address occupational safety, security, ergonomics and emergency management needs in the design development process and set out a process to identify hazards, rate the risk of the hazard and carry-out re-design work to prevent or minimize the risk posed by work-related hazards associated with the operations and maintenance of facilities.

2.8 Environment by Design

An Environmental Management Plan (EMP) will be created to outline, regulatory requirements and broad-level mitigation measures to be implemented during construction. A separate Construction Environmental Management Plan (CEMP) for the project will be the responsibility of the DB proponent to meet or exceed the standards laid out in the EMP based on studies performed in the area and general best management practices. Contractor-provided CEMP's are more effective as they are more reflective of the specific methods to be employed during construction, the seasonal timing of the work, and finalized project designs.

The EMP the CEMP to include (at a minimum) the following:

a. Environmental Monitoring Plan
b. Erosion and Sediment Control Plan
c. Site Delineation and Protection of environmentally sensitive areas.
d. Plans for the restoration of sensitive habitats.
e. Access Routes that mitigate impacts to nesting sites, riparian zones, and aquatic habitats, etc.
f. Fuels, hydrocarbons, and Hazardous Materials spill response plans.
g. Fire Prevention Plan
h. Communications Plan

3. Licensing and Permits

3.1 Overview

3.2 BC Environmental Assessment Office

The BC Environmental Assessment Office (EAO) of the Ministry of Environment is responsible for the management of Environmental Assessment (EA) for proposed major projects as required by the *Environmental Assessment Act* (EAA).

According to the Reviewable Projects Regulation of the BC EAA, an EA is required when CVRD eventually increases their license to divert more than 10Mm^3 per year. While this threshold has been confirmed with the EAO, the existing license held by CVRD is only 9.1 Mm^3 per year. A draft Project Description was submitted in July 2017.

In July 2017, after submission and review of the first draft of the EA Project Description, it was determined by the Canadian Environmental Assessment Agency (CEAA), that the project was not described in the *Regulations Designating Physical Activities* and therefore did not require an Environmental Assessment under the CEAA. However, as the Project undergoes detailed design, the CVRD may be required to submit additional descriptions to the CEAA for review to determine if any planned activities will trigger the Regulations.

3.3 Ministry of Forests, Lands, and Natural Resource Operations

The Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO) is the Province's land manager, responsible for stewardship of Provincial Crown land, cultural and natural resources including water references.

3.3.1 Change of Works Application

An amendment to CVRD's existing water licence is required to change the intake location from the Puntledge River (through the BC Hydro penstock) to Comox Lake. The amendment will occur through a 'Change of Works' (COW), which will be processed through FrontCounter BC, who will accept the application once all the submission requirements are met. There is a $1,000 processing fee due at the time of submission.

Once the application is accepted, the file will be passed to MFLNRO who will manage the COW. MFLNRO will look at multiple aspects of the Project as part of the amendment, before making a decision. This includes environmental impacts, land owner impacts, and consultations. A new Water Use Agreement with BC Hydro will be required before the amendment is processed. A water license amendment reactivates CVRD's existing water licence, allowing the Comptroller of Water Rights to impose new conditions onto the licence (for example, flow restrictions to maintain fish flows). The initial submission documents to FrontCounter BC are included in Appendix C.

3.3.1 Stream Crossings

For any creek crossing, MFLNRO must be consulted under Section 11 of Water Sustainability Act. It is anticipated there will be two crossings of Bevan Creek as well as construction within the lagoon. The DB Contractor will be required to undertake this consultation, as the design and installation details of the crossings must be provided to MFLNRO. Following review by MFLNRO, one of two permitting processes must be followed for each crossing:

- Notification – if there are no changes "in or about a stream", MFLNRO requires a notification of the work. A permit will be granted within 30 days.
- Approval – If there are "changes in or about a stream", design and installation details must be submitted to MFLNRO, consultation will be required, and an impact assessment completed. This process can take between 140 days and several months.

3.4 Ministry of Transportation and Infrastructure

The Ministry of Transportation and Infrastructure (MOTI) is responsible for transport infrastructure and law.

3.4.1 Permission to Act as an Agent

Any party submitting an application to the MOTI on behalf of the CVRD must do so as an agent of CVRD, by completing and submitting **Form H1275 – Permission to Act as an Agent**, which requires CVRD's signature.

3.4.2 Provincial Public Highway Permit

To route the pipeline across an MOTI right of water (ROW) requires submission of Form H0020 - Application for Permission to Construct Works within Highway Right-of-Way.

This permit will establish the ROW for the pipeline crossing of the highway. This permit does not allow for actual work to be performed within the ROW. The actual work requires a Work Notification/Lane Closure Request.

Opus will prepare and submit this application on behalf of CVRD, who will hold the permit.

3.4.3 Work Notification / Lane Closure Request

For work occurring within an MOTI ROW, if traffic will be disrupted on a MOTI highway, **Form 1080 Work Notification Lane Closure Request** must be submitted by the DB Contractor to MOTI.

3.5 Ministry of Environment

Any work conducted within or any discharges made to Riparian Areas must meet with the requirements of the Riparian Areas Regulation (RAR) which will require that a Qualified Environmental Professional assesses the proposed activities to ensure the Riparian Area is protected.

3.6 Department of Fisheries and Oceans

Fisheries and Oceans Canada (DFO) manages the Fisheries Act as well as the Navigable Waters Act.

3.6.1 Projects Near Water – Proponent Self-Assessment

The Fisheries Act requires that projects avoid causing harm to fish unless authorized by the DFO. This applies to work being conducted in or near waterbodies that support fish that are part of or that support a commercial, recreational or aboriginal fishery.

For any work with potential impacts to fish habitats and Species at Risk Act (SARA)-listed aquatic species, a Self-Assessment[1] for the project is required.

The DB Contractor will be responsible to prepare and submit to DFO all self-assessments for work which may cause harm to fish. DFO's review will generate a list of recommendations that must be followed by the DB Contractor.

3.6.2 Navigable Waters Act

The Department of Fisheries and Oceans controls the navigable water requirements for boat traffic. Clearances are typically 3.0 m depth between the law and low water levels.

The requirements from DFO should be obtained in writing from an authorized official of the Department of Fisheries and Oceans or the Provincial Ministry of Environment.

3.7 BC Hydro

BC Hydro (BCH) is a Crown corporation and is responsible for power generation in the Province. They manage the water in Comox Lake, and operate a power generation facility on the Puntledge River.

3.7.1 Water Use Agreement

The CVRD has Water Use Agreement with BCH, which allows them to withdraw water BCH's penstock. The existing agreement expires at the end of 2017..

[1] The assessment and process is described http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html

3.7.2 Worker Protection Practices

Worker Protection Practice (WPP) training is required for all personnel who will be working on or accessing BCH land. This is a generic BCH training program with two categories, Category A and B, which apply to differing levels of disturbance. BCH will determine which category of training is required depending on the planned activities to be completed on BCH lands by the individuals. Once WPP training is complete, all site personnel will require Local Component Training, which is site specific training by BCH. The DB Contractor will be responsible for coordinating with BCH to obtain all required training for their workers.

3.7.3 Temporary Land Access Permit

All works performed on BCH land require consent from BCH. The DB Contractor must notify BCH of any work to occur on BCH land and will be responsible for submitting all necessary documentation. At a minimum, the documentation required will include a work plan describing all proposed works, an environmental management plan, a public engagement safety plan, and archeological "chance find" procedures (which are already prepared).

The work plan is subject to BCH review and approval before land access is granted. The DB Contractor will be responsible for providing all necessary submissions to BCH to obtain permission to perform work on BCH lands. As work becomes more complex and intrusive, timelines for BCH review will increase.

3.7.4 Application for Use of BC Hydro Property

A land use application must be submitted to and approved by BCH for the installation of pipelines which will cross BCH lands (raw water pipeline from pump station to WTP and treated water pipeline from WTP to reservoir), which will address the operational, safety and maintenance requirements for the infrastructure occupying the lands.

3.7.5 Power Service

The new WTP and RWPS will each require a new electric power service. The DB Contractor will be required to coordinate with BCH to obtain and pay for temporary power service to the sites for construction, the installation of the permanent power service from BCH will be arranged by the CVRD.

BC Hydro will extend an overhead power line from its Puntledge Substation to each facility to provide primary electric service. The CVRD will be responsible for the cost of this 25kV overhead power line extension to each site.

BCH will complete the construction of the overhead power lines and, after inspection by BCH of each completed facility, the connections will be completed. The DB Contractor will be required to coordinate the connection and inspection of the completed construction to allow for the connection by BCH.

3.8 Vancouver Island Health Authority

3.8.1 Notice of Construction in Water

Vancouver Island Health Authority (VIHA) has been notified that construction will disturb the Comox Lake and may increase turbidity in the lake, potentially impacting water quality. The Health Authority will be notified of the dates for construction so they can take measures to mitigate for the expected increased turbidity.

3.8.2 Construction Permit

VIHA will provide a construction permit[2] upon their approval of final "Issued for Construction" drawings and specifications. Opus will keep VIHA informed of the project during the Indicative Design process. Submission of the Construction Permit Application will be the responsibility of the DB Contractor.

[2] Requirements for the permit are provided in the following weblink: http://www.viha.ca/NR/rdonlyres/71A5047A-4E40-43A3-A6ED-32C60041FCCC/0/GUIDELINESFORTHEAPPROVALOFWATERWORKS.pdf

3.8.3 Commissioning / Hand-over Plan

VIHA must review and approve the Commissioning and Hand-over Plan for the new facilities. This will be the responsibility of the DB Contractor.

3.8.4 Water Treatment Plant Sewerage System

A septic field disposal will be provided for wastewater disposal at the water treatment plant. All sewerage systems must be compliant with the Provincial *Sewerage System Regulations* and VIHA requirements for sewer systems[3]. The DB Contractor will be responsible for the design and permitting required in accordance the Provincial *Sewerage System Regulations.*

3.9 Hancock Forest Management

Hancock Forest Management (HFM), also doing business as Comox Timber is the owner of the proposed WTP site and the treated water pipeline.

3.9.1 Temporary Land Access

A land access permit is required to enter onto and to complete work on HFM lands. A work plan must be submitted and insurance requirements met to obtain an access permit. A land access permit is issued by HFM following review of the submitted documents. The DB Contractor will be responsible for determining if any work on HFM land is required and applying for land access permits if necessary.

3.9.2 Land Acquisition

Acquisition of the land parcel for the WTP by CVRD is on-going, and is being undertaken by CVRD.

3.9.3 Statutory Right of Way (SROW)

CVRD will require a Statutory ROW for the raw water and treated water pipelines that will cross HFM land to/from the WTP parcel. The need for an SROW, and its alignment and proposed size will be part of the process for the land parcel acquisition being conducted by CVRD.

3.10 TimberWest

Timberwest is a major land owners in the Comox Valley and practice forestry in the Comox Valley. They own the most of the Comox Lake bed.

3.10.1 Temporary Land Access

Work on TimberWest land requires authorization. There are no formal requirements, however, a request to enter and work on TimberWest must be submitted and approved. The DB Contractor will be required to contact TimberWest to obtain permission for access and construction requirements to work on TimberWest.

3.10.2 Statutory Right of Way

TimberWest has an interest in any works which may be constructed on the Comox Lake bed and have given conditional consent to CVRD for installation of the intake. CVRD may also require a Statutory ROW for the treated water pipeline crossing over TimberWest roads.

3.11 Courtenay and District Fish and Game Protective Association

The proposed raw water pump station is located on land owned by the Courtenay and District Fish and Game Protective Association (CDFGPA). The CDFGPA is a private organization which conserves, enhances and promotes the management and utilization of natural resources in an ecologically sound manner.

3.11.1 Temporary Land Access

Access to and any work being done on the CDFGPA lands requires permission from CDFGPA.

[3] Reference to VIHA requirements for sewerage systems can be found at the following weblink: http://www.viha.ca/mho/Land_Use.htm.

The DB Contractor will be required to obtain permission from CDFGPA to access CDFGPA land, and for any construction work is to completed on CDFGPA land.

3.11.2 Land Acquisition

Acquisition of the land parcel for the raw water pump station site is on-going, and is being undertaken by CVRD.

3.11.3 Statutory Right of Way

CVRD will require a Statutory ROW for the raw water pipeline that will cross CDFGA land from the raw water pump station parcel. The need for an SROW, and its alignment and proposed size will be part of the process for the land parcel acquisition being conducted by CVRD.

3.12 Comox Valley Regional District

3.12.1 Building Permit for Raw Water Pump Station - Complex/Commercial Buildings

Prior to construction, a building permit will be required for the raw water pump station. The facility is classified as Utility Resource under Bylaw No. 2781 “Comox Valley Zoning Bylaw, 2005” and can be constructed without re-zoning the land. It will be the responsibility of the DB Contractor to prepare and submit the building permit application.

3.12.2 Building Permit for Water Treatment Plant - Complex/Commercial Buildings

Prior to construction, a building permit will be required for the WTP. The WTP is located on Rural Twenty (RU-20) land use #802. The facility is classified as Utility Resource under Bylaw No. 2781 “Comox Valley Zoning Bylaw, 2005” and can be constructed without re-zoning the land. Building and Riparian setbacks will be governed by the zoning Bylaw No. 2781. It will be the responsibility of the DB Contractor to prepare and submit the building permit application.

3.12.3 Development Permit – Pump Station

A development permit is required as a part of the Pump Station land acquisition and will be led by CVRD.

3.12.4 Development Permit – Water Treatment Plant

A development permit is required as a part of the Water Treatment Plant land acquisition and will be led by CVRD.

3.13 Fortis BC

Fortis BC the local gas distribution company in the area of Courtenay and Comox. The Oil and Gas Activities Act (Sec. 76) requires that written permission must be obtained prior to commencing an activity within 30 metres of a high-pressure pipeline.

FortisBC has design requirements for installing pipelines which cross transmission pressure (TP) gas mains. These requirements differ based on whether the pipeline crosses above or below the TP main. The design is also subject to review and approval by FortisBC and their permits[4].

The DB Contractor will be responsible for obtaining a gas crossing permit from FortisBC. The Transmission Operations Manager in the area can be contacted to discuss the design of the crossing prior to completing the design.

3.14 First Nation Archaeology Requirement

An Archaeology Overview Assessment (AOA) was completed during the Project Definition phase. The assessment concluded that: *“No further archaeological work is recommended for either of the potential pump station site, or the proposed water treatment facility sites.”*

[4] Fortis permit requirements are described at: https://www.fortisbc.com/Safety/NaturalGasSafety/Pages/Right-of-way.aspx.

A Chance Find Protocol was prepared by Baseline Archaeological Services Ltd. for use by CVRD and field investigations and was reviewed by BC Hydro. The same protocol would be applicable for the construction period. The DB Contractor will be required to adhere to this document and follow the necessary procedures if a 'chance find' occurs. The AOA was included with the Project Definition Report. The Chance Find Protocol is in Appendix D.

3.15 City of Courtenay

Based on the recommended connection of the City of Courtenay sanitary sewer system, the project will need to comply with the Sanitary Sewer Use, Extension and Connection Bylaw No. 1327.

3.16 Summary

The following table summarizes the permits required and the party that is responsible for obtaining the permit.

Agency	Permit	Obtaining Party	
		CVRD	DBC
MFLNRO	Water License Amendment	X	
MFLNRO/MOE	Stream Crossing		X
MOTI	Permission to Act as an Agent- H1275		X
MOTI	Permission to Construct Works w/in Highway ROW	X	
MOTI	Work Notification/Lane Closure Request –Form 1080		X
MOE	Riparian Area Regulation		X
DFO	Species at Risk Self-Assessment		X
BC Hydro	Water Use Agreement	X	
BC Hydro	Worker Protection Practices training		X
BC Hydro	Permission to Access	X	X
BC Hydro	Land Use Application for Statutory Right of Way	X	
BC Hydro	Power Services		X
VIHA	Notice of Construction in Water		X
VIHA	Construction Permit		X
VIHA	Commissioning / Hand-over Plan		X
VIHA	Water Treatment Plant Sewerage System		X
Hancock Forest Management	Temporary Land Access Permit	X	
Hancock Forest Management	Land Acquisition	X	
Hancock Forest Management	Statutory Right of Way	X	
TimberWest	Temporary Land Access		X
TimberWest	Statutory Right of Way	X	
Courtenay and District Fish & Game Protective Assoc	Land Acquisition	X	
CVRD	Building Permit for Raw Water Pump Station		X
CVRD	Building Permit for WTP		X
CVRD	Development Permit – Pump Station	X	
CVRD	Development Permit – WTP	X	
Fortis	High Pressure Gas Main Crossing		X
City of Courtenay	Connection to Sanitary System (if required)		X
First Nation Archaeology Requirement	Chance Find Protocol		X

4. Raw Water Submerged Intake Screen

4.1 Overview

This section presents the requirements and design criteria for the submerged intake screens. Location for the intake depth and elevation was determined in the PDR. Location for the horizontal alignment was adjusted following the hydrographic survey by Golder (Appendix A).

4.2 Location Conditions

The raw water intake screens will be constructed in Comox Lake and located approximately 1,100 meters south of the Raw Water Pump Station as shown on Drawing No. C-2001. The intake structure will be interconnected with the pump station wet well via a marine (submerged) pipeline, about 850 meters of which will be placed directly on the lakebed and approximately 266 meters which will be buried under the lagoon at the north end of the lake (Sections 5).

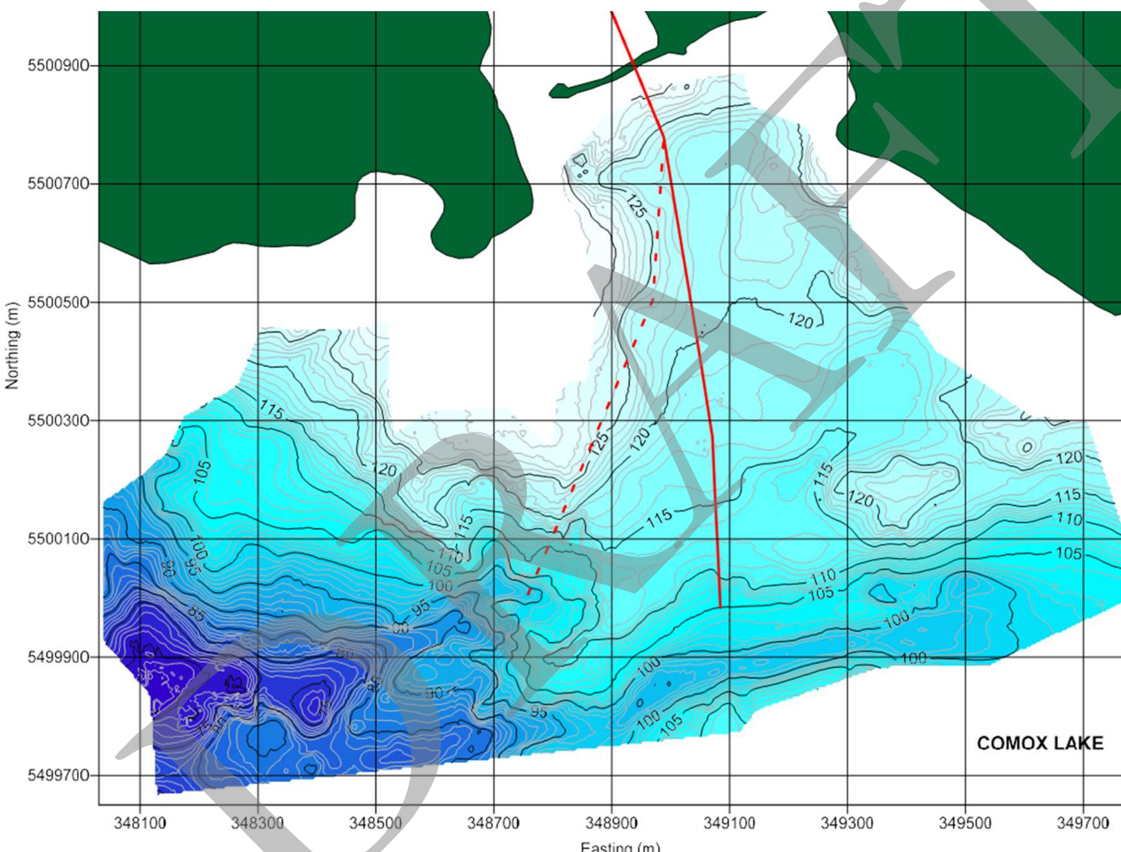

Figure 4-1 Raw Water Intake

4.2.1 Intake Flow Requirements.

Design flowrate is per Table 2-1. The raw water intake is expected to be operating during all months of the year. For the 143 ML/d WTP ultimate flow condition, lake diversions would vary seasonally from about 50

ML/d (winter) to 140 ML/d (summer). For initial project operation (2019 – 2029), lake diversions are expected to vary seasonally from about 15 ML/d (winter) to 70 ML/d (summer).

4.2.2 Water Quality Conditions.

CVRD has been measuring turbidity and other water quality parameters at the location of the raw water intake since 2011. Except for occasional turbidity events, normal turbidity was measured to be below 1 NTU.

Zebra and quagga mussels have infested lakes and rivers in the American midwest and pose a threat to water diversions as the adults can form mats on the screen face blinding off the screen face and risking cavitation of wet well pumps and immature stage can pass through typical fish screens and infest other submerged portions of the water supply. These organisms are not anticipated to pose a threat to the Comox raw water intake as they typically require calcium above 10 mg/L (average Comox Lake calcium is 5.1 mg/L).

4.2.3 Other Lake Conditions

Water Surface Levels. Seasonal variations in lake water surface levels occur. Lake surface elevations ranged from 136.0 meters to 130.5 meters over the period 1993 to 2016. (PDR, 2016 – Section 3, Table 3-1)

Lake Currents. Lake currents in the area of the raw water intake have not been measured however are not expected to be significant given the deep-water location.

Water Temperature and Thermal Effects. Lake water temperature variations have been measured, (PDR, 2016 – TM 3, Section 3.2) and vary between 5°C and 11°C at screen depth. HDPE pipe of the type planned for construction of the marine pipeline exhibits a high coefficient of thermal expansion. If the pipe is unrestrained, it will expand or contract in length as a result of temperature changes. If the pipe is restrained, internal pipe stresses (tensile or compressive) will develop during temperature changes. If the compressive stress level exceeds the column buckling resistance of the restrained length, then lateral buckling (or snaking) will occur. While thermal stresses are well tolerated by HDPE pipe, anchored or restrained pipe may apply stresses to restraining structures, such as the raw water intake. The resulting stress or thrust loads can be significant and the restraining structure(s) must be designed to resist the anticipated loads.

Boating and Recreation. Based on current use of the lake, anchors commonly used by recreational boating or commercial craft are not expected to adversely affect the raw water intake; design of protective measures is not required.

4.2.4 Raw Water Intake Isolation

The pump station wet well will be isolated at the wet well to satisfy wet well inspection safety requirements. No isolation (i.e. isolation valves) will be provided at the raw water intake screens either for establishing a double block-bleed at the wet well, or for inspection of the marine pipeline. The raw water intake and marine pipeline will not be isolated from the lake and/or dewatered at any time.

4.2.5 Cleaning System

Given the screen location and depth, and reports that the existing water quality sample system intake screen is in a clean condition after several years of service (CVRD maintenance records), a fish screen cleaning system will not be included as part of the project. However, DFO recommends that passive screens incorporate additional screen open area (up to four times). Because, the screens are being sized for 0.11 m/sec for 143 MLD ultimate flows (Year 2069), and the initial project flow is only 76 MLD, the maximum approach velocity during initial operation will be 0.055 m/sec. Essentially the screen open area will be two times the minimum required for the first 10 years of operation. The screen condition can be monitored and cleaned manually by divers, every 10 years or more, as-needed. The addition of more screens also be accomplished in the future.

4.3 Regulatory Guidelines

The raw water intake will be designed to comply with the criteria and requirements specified by the Canada Department of Fisheries and Oceans (DFO) for the subcarangiform fish species swimming mode, as follows:

a. Maximum approach velocity on open area = 0.110 m/sec.
b. Maximum screen size opening = 2.54 mm.
c. Cleaning and regular maintenance: provisions for the removal, inspection and cleaning of screens. Screens may be cleaned by methods such as flushing with air or water, backwashing, removing and pressure washing, or scrubbing.
d. For screens that will not be cleaned regularly, DFO recommends that the screen design consider providing more open screen area in addition to the minimum open area required based on maximum approach velocity.

4.4 Geotechnical Conditions

Geotechnical and geophysical investigations for the raw water lake intake were conducted in April / May 2017 and documented in the Golder Associates draft report dated June 21, 2017. (Appendix A)

In general, the Comox lakebed largely consists of a 1 m to 2 m thick layer of soft sediments overlying harder sub-bottom layers. At the proposed intake location (as depicted for ST7 as shown in Figure 5.1 below), Golder Associates reported that there is a 1.0 m to 1.5 m thick layer of soft sediments. However, at a location approximately 70 m to the south of ST7 (Point "A" as shown) or 10 to 15 m north, there is a narrow ridge that Golder Associates interpreted to be composed of hard sediments or rock and suggests this may be a more suitable location for the raw water intake.

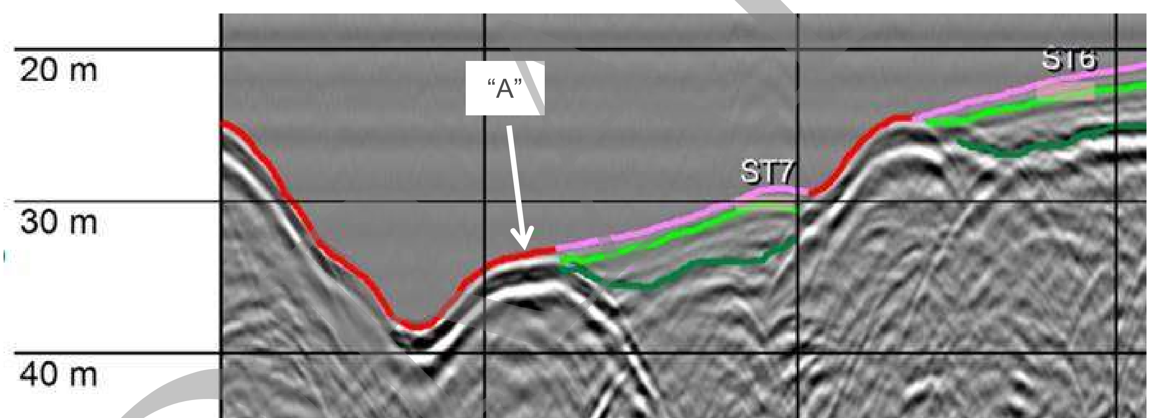

Figure 5.1: Sub-bottom Profile Results (Golder Associates Draft Report, Figure 7)

4.5 Proposed Intake Screen Location

Based on the subbottom profiling performed by Golder Associates, the foundation conditions for the intake screen will be significantly improved by relocating the intake structure approximately 70 m to the south to take advantage of the existing hard lakebed geology. The more formable lakebed geology is also 10 to 15 meters north but at a 20% slope. The expected structural and construction risk benefits of relocating the raw water intake include:

a. Reduced construction risk of encountering unknown thicknesses of soft sediments.
b. Greater allowable bearing pressures of in-situ materials may reduce the structural footprint of the concrete foundation pedestal.
c. Reduced risk of long-term differential settlement.
d. Straightened alignment simplifies float and installation.

4.6 Intake Screen

The raw water intake structure layout is shown in Drawing M-2001. For construction purposes and ease of installation, the intake includes the following components:

Foundation Pedestal. The foundation pedestal is shown as a 5 meter long by 5 meter wide by 1.2 meter high reinforced concrete H-shaped structure that will be placed on the lakebed to serve as the foundation for the intake. The structure can be pre-cast as a single piece on shore and barged to the installation site. It will be placed in a trench that is constructed underwater in the lakebed and then grouted in-place.

Intake / Fish Screen Assembly. This assembly consists of the two cylindrical fish screens (T-screens), intake header pipe, and structural support. It can be pre-fabricated on shore and completely pre-assembled with the foundation pedestal for fit-up purposes. After the foundation is installed, the intake can be barged to the installation site and lowered onto the foundation. The marine pipeline will connect to the flanged end of the intake header pipe.

Flexible Connection between Intake and Foundation. The connection between the foundation pedestal and intake assembly will be configured to allow for flexibility of movement due to marine pipeline thermal expansion/contraction as noted above. The direction(s) and amount(s) of movement(s) will be determined during final design of the marine pipeline in order to design the corresponding flexible connection between the intake assembly and the foundation.

Requirements for Design of Intake against Flotation. As noted above, the intake and marine pipeline will never be isolated and dewatered for any purposes. Therefore, design of the intake structure against flotation / uplift is not required.

4.7 Construction Requirements

In general, the intake screen fabrication and foundation construction will likely be performed onshore at a staging area and the installation performed entirely underwater by staging marine operations from the lake surface.

Placing and leveling the foundation pedestal can be performed by a diving crew with appropriate equipment or, alternatively, by remote operation of underwater trenching equipment. Identification of the appropriate equipment can be determined in final design by the DB Team. Underwater construction will be carried out using siltation curtains enveloping the work area to protect water quality.

Once the foundation is placed into the trench by lowering it from the barge, it can be solidly locked into place by placement of tremie concrete to backfill voids between the concrete surfaces and trench walls.

4.8 Intake Fish Screen Criteria

The raw water fish screens will meet the criteria established by DFO. Requirements are summarized in Table 4.1 below.

Table 4.1: Raw Water Intake Fish Screen Criteria

Requirement	CRITERIA	REMARKS
Number of Fish Screens	2	
Design Flow (per screen), ML/day (ft^3/sec)	71.5 (29.2)	
Total Intake Design Flow, ML/day (ft^3/sec)	143 (58.5)	
Maximum Approach Velocity, m/sec, (ft/sec)	0.110 (0.36)	
Maximum Design Opening, mm (inches)	2.54 (0.10)	
Effective Area (%)	58[(a)]	
Minimum Screen Surface Area Required (m^2)	25.5	
Screen Type [(b)]	Cylindrical welded V-wedge (0.069”)	
Materials	Stainless Steel	AISI Grade 316L
Design Temperature	2 to 12 °C	

Notes:

a. Varies by manufacturer
b. Cylindrical tee screens are recommended because they can be easily removed (are bolted onto the intake header pipe flange) and replaced if damaged or require major cleaning or repair.

5. Raw Water Intake Pipeline

5.1 Overview

This section describes the design for the raw water intake pipeline. The raw water intake will extend into Comox Lake and be used

5.2 Design Criteria

The marine pipeline will be designed for two design operating conditions. The primary design condition will be to divert water from Comox Lake to be pumped to the WTP. The second condition will be to allow any water surges resulting from sudden pumping stoppage to be conveyed back to the lake. The pipeline design will be designed for the expected losses under both flow directions. The following table summarizes the key design parameters for the marine pipeline.

Table 5-1 Marine Pipeline Design Criteria

Parameter	Value
Operating Conditions	
Maximum Design Flow, m^3/sec (ML/day)	1.7 (143)
Maximum Surge Flow Conveyed to the lake, m^3/sec	1.7
Maximum Velocity, m/s	1.0
Maximum Head Loss (when drawing water from the lake), m	1.9
Maximum Head Loss (when conveying surge back to the lake), m	1.2
Physical Parameters	
Pipe Length, m	1170
Pipe Material	HDPE SDR 26
Pressure rating, kPa (psi)	450 (65)
Hazen Williams Roughness Coefficient (HDPE)	140 - 150
Pipe outside diameter, mm (inches)	1600 (63)
Pipe wall thickness, mm (inches)	61 (2.423)
Pipe inside diameter, mm (inches	1469 (57.8)
Pipe material specific gravity	0.93 - 0.96
Pipe weight, kg/m (lbs/ft)	300.6 (202.01)

5.3 Alignment and Depth

The alignment of the marine pipeline will generally follow the design shown in Drawing C-10-01. The marine pipeline will be designed to ensure that the most stable, economic, and constructible alignment is selected, ensuring that the highest water quality is obtained from the intake. The marine pipeline alignment will be designed with sufficient continuous grade to ensure that air does not get entrained or collect along the pipe length. A minimum grade of 2% is recommended for the on-shore approach sections to prevent air accumulation. The minimum radius of curvature of the piping during construction will not be less than thirty times the pipe diameter or 42 m.

From the available raw water quality data and temperature data, it is determined that the lake intake be located at approximately 28.8 m depth below average water level at the intake location. This equates to an elevation of approximately 105.0 m. The lake intake will be situated off the lake bed by approximately 1.5 m to reduce the chance of lake bottom silts, fish or other marine life from being drawn into the marine pipeline. Therefore, the target depth for the intake at lake-bottom is 27.3 m.

DFO requires a minimum of 3.0 m of water, at Low Water Level, above any pipe that is not buried to provide clearance from marine/boating traffic. Accounting for the 3.0 metre depth for navigation and the 2.0 metre pipeline profile, the pipe will have to be buried in the lake bottom where the depth is 5.0 m below the DFO approved Low Water Level. The historical low water elevation is 130.2 m, and therefore, the pipe can be laid on the lake bottom at elevation 125.2 m and below.

5.4 Pipe Construction and Ballasts

The marine pipe will be HDPE assembled using thermal butt fusion or flanged connections at specific points. Butt fusion jointing method will be implemented on-shore. Flange connections will be used to connect the pipeline to the screen assembly and for transition between pipe materials at the Raw Water Pump Station.

As HDPE pipe is less dense than water, ballast weighting will be required to ensure that the pipeline remains at lake bottom once installed. Weighting of ballasts will be a minimum of 20% of the empty buoyant force of the pipe. Ballast spacing is to be in the range of 3.5 m to 4 m on centre for the full length of the submerged pipe. The bottom section of the ballast will be heavier than the top portion to prevent rotation of the pipe during installation. The concrete ballast weights will be numbered on top with 100 mm high numbers, using a white waterproof paint to enable coordination of their location in post construction video work and for future maintenance activities.

5.5 Marine Pipe (Lake-Bed) Installation Requirements

5.5.1 Marine Pipe Installation Plan

The Proponent will be required to submit the marine pipeline design and construction plans to demonstrate the suitability of the approach, subgrade conditions, alignment and intake location. The Proponent's Installation plans will show and describe the following:

a. *Assembly area layout, method of monitoring and recording joint welding, method of pulling pipe sections on to the water surface, pressure testing, details of ensuring horizontal alignment, details of method for joining pipe sections and lowering pipeline onto lake bottom including calculations to show maximum stresses on pipe, pulling and lowering line spacing, method of controlling lowering operation, method of controlling uniform loading on the lake bottom during installation, method of connecting diffuser section, method of recovering pulling lines and other installation gear.*
b. *Analysis of the float and controlled sink method with the specified pipe, weighting and bottom profile, based on a single length deployment. The end tension and internal pipe pressure values to limit the minimum radius of curvature to 30D are to be shown.*
c. *Calculations demonstrating maximum permissible stresses are not exceeded during installation and operation.*

5.5.2 Installation Requirements Tolerances

The pipeline installation will result in disturbances of sediments. To prevent negative impacts to the surrounding environment and disturbances to the water quality being diverted to the CVRD community water supply, the Proponent will utilize underwater excavation by jetting, suction dredging, clamming, draglining or other approved methods in isolation of flowing water. Silt curtains will be required for all underwater excavations. Excavation will conform to the following criteria and tolerances:

- Horizontal tolerance ± 1.5 m
- Vertical tolerance + 0, -0.300 m
- Grade Tolerances +8.0%, -0% (maintain positive slope greater than 2% along marine pipe alignment and 0.3% along the foreshore)

Disposal of surplus and unsuitable excavated material from Comox Lake trench excavations will be to designated disposal sites approved by the MOE. The Design-Builder will be responsible for the arranging and payment of any disposal permits.

5.5.3 Location Markers for Intake

Hazard location marker(s) will be erected on land defining the location of the marine pipeline alignment. The sign(s) will be placed to be clearly visible to the area in which the intake is situated. The intake sign will include information to DFO standards.

5.5.4 Rip-Rap Protective Layer

Rip rap may be required over sections of the pipeline. Rip-rap, gravel or other rock material placed over the pipeline will be free of silt, overburden, debris or other substance deleterious to aquatic life. The rip-rap will be placed without causing any structural damage to the marine pipeline.

5.5.5 Quality Control Requirements

Pressure Testing - The marine pipeline will be pressure tested with water after the ballast weights are installed. This testing will be completed before the pipe is accepted for deployment of the float and sink.

The test area will be with a regular bottom profile to prevent damage to the pipe and weights. Alternately, supplemental flotation could be provided to keep the pipe from sinking during the pressure test.

The pipe will be tested for one hour at a 350 kPa (50 psi) test pressure. No leakage will be permitted. The test will include an allowance for volume change during the pressure test procedure.

Record of Alignment Survey - Record of alignment survey will be required to verify the final alignment meets the requirements of the Design Specifications.

Diving and Video Inspection - Following the installation of the marine pipe, the entire pipe alignment will be inspected by a diver, and surveyed with CCTV, in colour, to identify any defects. Diving will only be carried out by person experienced in commercial diving. Any defective work will be required to be rectified and the corrected area inspected again with a diver or a Remotely Operated Vehicle (ROV) to the satisfaction of the Owners Engineer.

5.6 Buried Section of Intake Pipe Installation

The reach of the alignment stretching from the pump station to the transition joint (Sta. 0+233) is proposed to be buried below the existing lake bed. At the transition joint, the lake intake pipe will transition from buried pipe to pipe installed on the lake bed. The buried portion of the intake pipe, is to be installed approximately 9 m below ground surface, measured ground surface to invert, and 10.95 m below the maximum lake level, measured maximum historical lake level to pipe invert.

The subsurface conditions within the project area are defined in the 2017 Golder Report (Appendix A). The anticipated subsurface conditions along the reach of buried pipeline, has been developed based on interpretation of the five boreholes advanced within the vicinity of the buried pipeline alignment. The subsurface soils have been classified into stratigraphic units and are anticipated to consist of fill material, underlain by sand and gravel, clayey sand and gravel interbedded with sand and bedrock. Physical characteristics of each of these stratigraphic units are described in detail in Appendix F.

The alignment and subsurface conditions noted in each borehole are shown on Figure 5-1. There are two boreholes which extend from ground surface to the depth of the buried pipeline[5] (BH17-04A in the spit and BH17-03 at the RWPS).

[5] Since industry standard would be boreholes spaced at 100 metre intervals along the buried pipe alignment, additional bore holes along the alignment are planned to be complete in fall 2017.

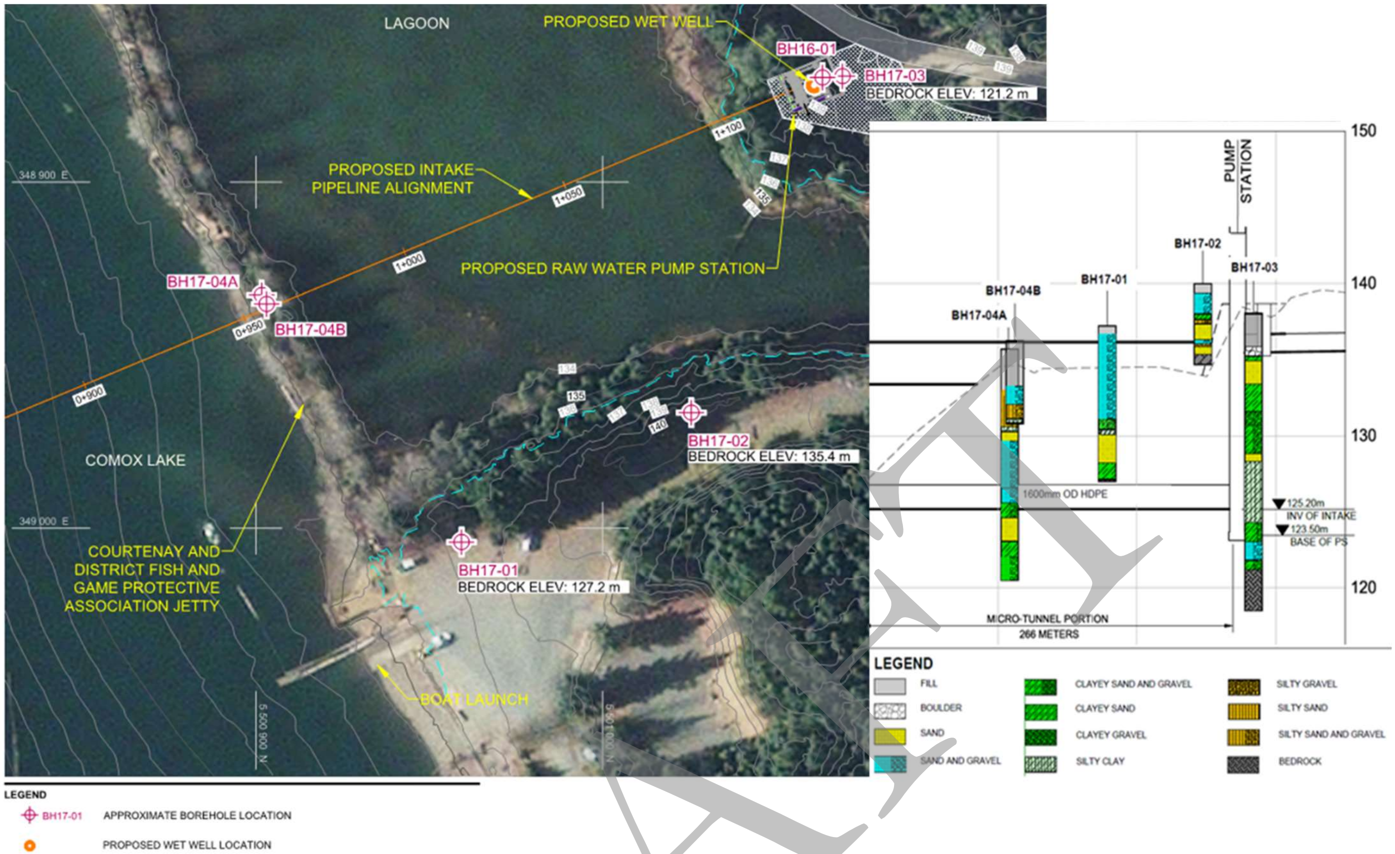

Figure 5-1: Buried Pipe Subsurface Profile

In consideration of the limited geotechnical data available and the associated challenges in interpolation the subsurface conditions at the elevation of the buried pipeline, the feasible construction alternatives will be capable of excavation of all soils noted within the project vicinity. Two feasible methods of excavation include (a) tunnel excavation utilizing a pressurized face microtunnel boring machine (MTBM), and (b) open cut dredging excavation

Open face tunnel excavation was not considered as a feasible construction method due to the potential to encounter flowing sand and gravel located below approximately 1 bar of water pressure in the tunnel face.

5.6.1 Microtunnel Boring Machine (MTBM) Excavation

Tunnel excavation with a pressurized face MTBM has been identified as a feasible construction method. This construction approach involves the following process;

- Support and excavation of the pump station sub-structure, this excavation will be utilized as the MTBM jacking shaft prior to fit out of the pump station concrete;
- Installation of the concrete reaction block to bear jacking thrust loads required to push the MTBM and pipes forward. Installation of the shaft seal to prevent lake water and ground intrusion while excavating out of the MTBM jacking shaft under pressure;
- Microtunnel construction of the buried portion of the raw water intake. In this process, the MTBM is pushed out of the shaft utilizing the jacking system connected to the stationary reaction block. After the MTBM is pushed forward, the jacks on the thrust frame are retracted and a 3.0 m pipe is put in place in the shaft behind the shield. The jacks push the pipe and MTBM forward 3.0 m out of the shaft, after

each push the jacks retract and a new pipe section is inserted. This process is repeated to complete the buried portion of the raw water intake.

- The MTBM will emerge into the lake bed upon completion of the buried portion of pipeline. Prior to emerging into the lake, the MTBM excavation chamber pressure will need to be lowered. Lowering the pressure in the excavation chamber will reduce material being pushed out into the lake.
- The last pipe section will need to stick out into the lake bed to allow connection to the pipeline installed on the lake bottom. The last pipe will need to be sealed internally to prevent water ingress through the completed pipe into the pump station excavation prior to the removal of the MTBM. The last few pipes installed with the MTBM will need to be weighed down to ensure it does not float after disconnection of the MTBM.
- Following completion of the MTBM excavation and pipe installation, contact grouting around the buried pipe annulus to fill any voids between the pipe and excavated ground surface.

Figure 5-2: MTBM used on Escondida Water Supply Project

Figure 5-3: MTBM Launched Under the Runway at Pearson Airport

Based on the anticipated subsurface conditions, sand, sand and gravel, clayey sand and silt clay below the groundwater table, the MTBM should be specified as a slurry type machine capable of withstanding 2.4 bar of water pressure. An earth pressure balance machine (EPBM) would also be suitable for excavation of the soil conditions encountered, however this type of machine has the risk of clogging at this diameter if boulders are encountered. Other specific machine details to be specified are provided in **Error! Reference source not found.** below.

Typically, in a microtunnel application reinforced circular concrete microtunnel jacking pipe in accordance with CAN/CSA A257 is specified to provide a rigid pipe designed to withstand the jacking forces it will be subjected to. However, the proprietary Northwest Pipe Interlocking Steel Casing Pipe, Permalok System, has also been utilized in British Columbia on the microtunnelling completed at John Hart Lake, this pipe system should also be considered.

Table 5-1: Proposed Microtunnel Equipment Specification

Item	Specification
Equipment	Slurry shield Microtunnel Boring Machine
Approved Manufacturers	Akkerman Inc Herrenknect AG mts Perforator GmbH Iseki Microtunneling Soltau Microtunnel Robbins
Design to withstand water pressure	2.4 bar or greater
Line Tolerance	50 mm
Grade Tolerance	40 mm
Pipe	RCP or Permalok®

Risks associated with microtunnnel construction include;

- Plume of sediment created in the lake bed posing a risk to the drinking water intake. This could occur as a result of a frac out of slurry from the MTBM excavation chamber if the chamber becomes over pressurized or during removal of the MTBM from the lake bottom.
- Encountering boulders and obstructions during the MTBM operation stopping the progress of the MTBM and requiring manned intervention to the face of excavation.
- Ground loss and flowable material is improperly controlled by the MTBM pressurized face leading to surface settlement and potentially flooding of the tunnel.

In consideration of these risks, it is recommended the following mitigation measures be implemented;

- A plan defining operating pressures for the MTBM needs to be developed by the Contractor. The operating pressures should be established based on specific tunnel reaches of similar geology and excavation conditions. Personnel knowledgeable of the subsurface conditions and microtunnel operation should be responsible for reviewing this plan.
- The planned slurry conditioning agent needs to be submitted by the Contractor and should specifically consider the subsurface conditions anticipated. Personnel knowledgeable of the subsurface conditions and slurry microtunnelling operation should be responsible for reviewing this plan.
- The Contractor should be required to submit a mitigation plan should pressure loss occur at the face of excavation.
- Settlement monitoring points should be installed on the MTBM excavation path adjacent to the pump station excavation to obtain readings prior to proceeding offshore.
- A turbidity curtain, refer to typical detail below, should be installed to prevent migration of sediment disturbed during excavation into the Lake and River. Monitoring of the turbidity curtain should be done daily to ensure it is continuous and to prevent mobilization of suspended silt outside the microtunnelling limits, turbidity monitoring could also be performed. It should be noted that sediment mobilization is not

expected during MTBM excavation until breakthrough into the lake bed and during removal of the MTBM equipment.

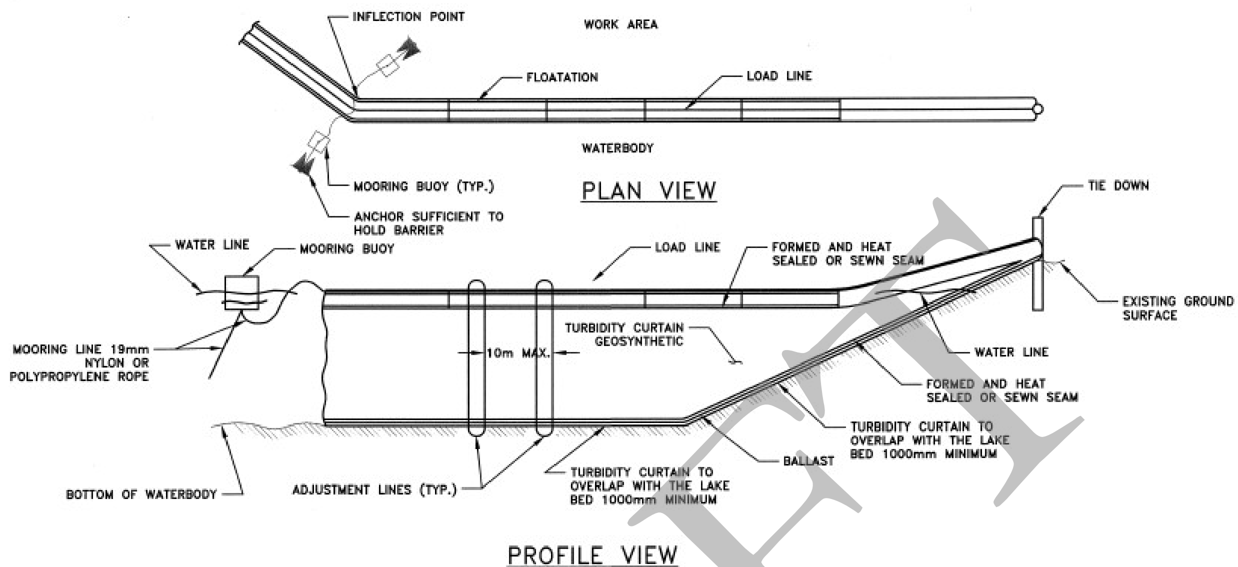

Figure 5-4: Turbidity Curtain Typical Detail

Figure 5-5: Removal of MTBM Within Turbidity Curtain

5.6.2 Open Cut Dredging Excavation

Open cut construction involves the incremental excavation of an underwater trench, otherwise known as dredging, along a shallow profile within the lake bed materials. Stone bedding will be placed in the bottom of the trench and then length of HDPE pipe are lowered into the trench, joined underwater, and backfilled. The dimension of the underwater trench is dependent on many factors. The depth of trench will be determined by the diameter of the HDPE, and the design intent to maintain cover over top of the pipelines to provide protection from anchors and other processes.

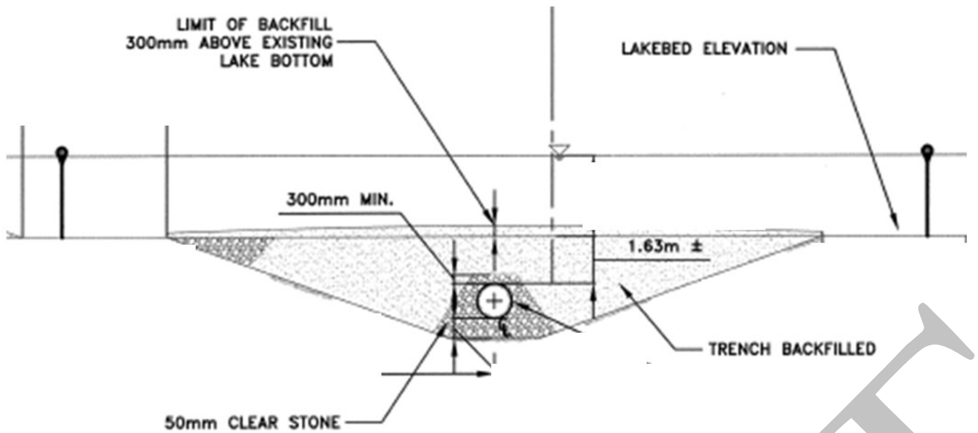

Figure 5-6:Typical Dredging Trench

Figure 5-7: Typical Dredging Setup

Risks associated with open cut dredging excavation include

- Plume of sediment created in the lake bed posing a risk to the drinking water intake. This would occur as a result of the dredging operation.
- Disruption to the boat ramp operation
- Buoyancy and flotation of the pipe

In consideration of these risks, it is recommended the following mitigation measures be implemented;

- A turbidity curtain needs to be installed on either side of the open cut trench to prevent migration of sediment disturbed during excavation into the Lake and River. Monitoring of the turbidity curtain should be done daily to ensure it is continuous and to prevent mobilization of suspended silt outside the dredging limits, turbidity monitoring could also be performed. It should be noted sediment mobilization is expected at all times during the dredging operation.

- If dredging is utilized communication with the local residents will need to be done to advise the boat ramp will need to be closed during dredging operation, due to the turbidity curtain being installed across the lagoon.
- Anti-flotation measures will need to be implemented to ensure the pipe does not float.

5.6.3 Evaluation of Feasible Methods

MTBM and open cut dredging both methods offer unique benefits. The MTBM solution mitigates the potential environmental impact and turbidity conditions of construction. This is accomplished by minimizing the potential activities causing sediment mobility and mitigating any impact to operation of the existing boat ramp. The dredging solution is expected to be a lower cost alternative, as it does not require mobilization of the specialized MTBM and associated support equipment.

The MTBM solution may be necessary to be specified for the DB proponent. Alternatively, the construction means and methods could be left to for selection. This approach would ensure the lower cost alternative is selected. However, the specifications would need to be developed to appropriately mitigate the associated risks this introduces, impact to the water quality and community boat ramp.

If the MTBM excavation method is selected, it is possible to construct the entire intake pipe alignment through MTBM methods. Since significant cost is expended upfront in securing and mobilizing the equipment to site (the MTBM, the slurry separation plant and the pipe jacking frame), once production starts, the incremental cost per metre is significantly lower than the overall cost per metre.

The length of the intake pipeline, approximately 1 km, should be feasible without intermediate shafts. However, further investigation of the subsurface conditions and jacking pipe restrictions would be required.

5.6.4 Contractor Staging Areas

For the MTBM option, a preferred space of approximately 50 m x 50 m would be desired to facilitate the operations of slurry separation plant (8 m by 10 m), tunnel spoil stockpile, jacking pipe laydown / staging area, contractor storage, MTBM crane pad and operator control cabin, and bentonite mixing tank space.

Truck movements and option for concrete batching/mixing (for annular grouting) at the site add to the space requirements. These space requirements are separate from the staging required for the HDPE marine pipeline.

The layout and orientation of the shaft with respect to the access road and positioning of other equipment must be reviewed in more detail to ensure construction is feasible without slowing logistics.

6. Raw Water Pump Station

6.1 Overview

This section describes the raw water pump station facility and site. Following the site survey, the actual property lines and logging road location were found to encroach on the facility as developed during Project Definition phase. Therefore, the building footprint was reduced by placing the electrical room on a second floor.

6.2 Pump Station Site Plan

A building superstructure over the concrete wet well will house the pump motors, piping and valves, electrical and control systems. The main floor of the building will be at elevation 138.5 metre. A standby diesel generator will be provided in an enclosure adjacent to the station.

6.3 Vertical Turbine Pumps and Wet-Well

The pump station includes a dry motor installation and pump suction column with open bowl assembly submerged into a wet well configured to meet Hydraulic Institute standards. A flow baffle wall is provided to ensure that the flow pattern approaching each pump bay is uniform and without flow vortices. The wet-well may be constructed as a rectangular structure within a contiguous secant caisson outer wall or within a circular caisson structure.

6.4 Pump Station Hydraulics

6.4.1 Surge Considerations

The operation of the pump station may be subject to transient hydraulic surge conditions during abnormal events such as loss of normal power supply. To mitigate the risk of transient surge conditions causing excessive high pressure waves at the pump station discharge, the station will be provided with transient surge protection using surge anticipating and relief valves discharging back into the wet well at a pre-determined rate of flow.

6.4.2 Pump Duty Selections

The ultimate station flow demand of 143 ML/day will require three (3) 41 ML/day pumps, two (2) 31.5 ML/day pumps and one (1) 41 ML/day pump as standby to cover the wide range of flow rates from 15.75 ML/day to 143 ML/day. All pumps will be equipped with variable speed drives to handle the wide range of flow demands. One 31.5 ML/day pump operating at 50% speed will be required to deliver the start-up minimum low winter flow rate of 15.75 ML/day.

The 41 ML/day (486 L/sec) pump rated at 31 m total dynamic head will have a maximum rated power demand of 176 kW requiring a motor rated at 186 kW (250 hp). The 31.5 ML/day pump rated at 31 m total dynamic head will have a maximum rated power demand of 135 kW requiring a motor rated at 149 kW (200 hp). The system head curves with pump selection curves noted above are shown in the following Figure 6.1.

Since the pipeline alignment and pipeline sizes were adjusted, the total dynamic head will have to be verified by the DB team.

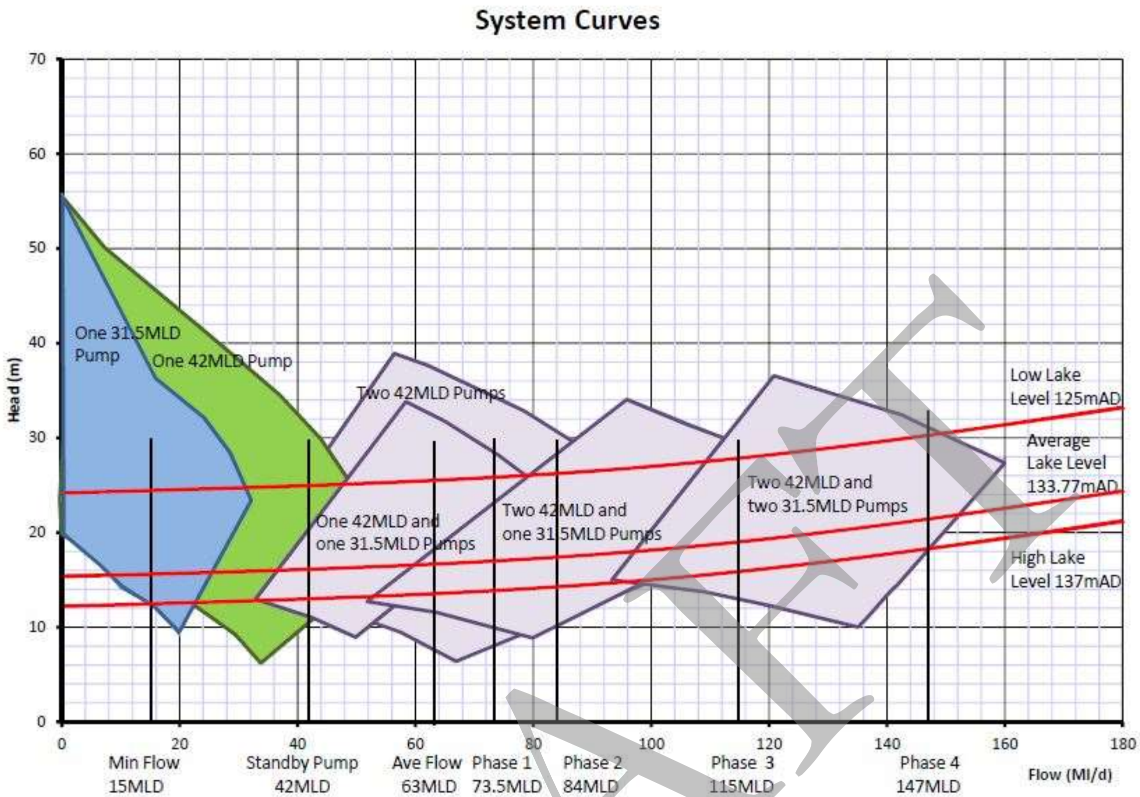

Figure 6-1 Pump Staging and Sizing

7. Water Treatment Plant

7.1 Overview

This section presents the sizing and design criteria for direct filtration, submerged membrane filtration and pressure membrane filtration for the project.

For membrane treatment, a 2-stage, high water recovery using either submerged membranes or pressure membranes will be considered. The residuals produced by the filtration will be treated and dewatered on site.

The hydraulic design criteria described in Section 2.0 has been applied for the sizing of the equipment and the plant.

Opus operated a comprehensive, 3-month jar testing program and dual media filter column pilot from April to June 2017. The findings from that program are presented in Appendix F. The investigations studies three different coagulants, filter loading rates, unit filter run volumes, backwash water characteristics, and disinfection by product formation. The data are applicable to both types of filtration (dual media sand and membrane).

7.2 Treatment Objectives and Standards

Further to the 4,3,2,1,0 approach adopted by VIHA described in Section 2.0, the plant will be designed to meet the *Guidelines for Canadian Drinking Water Quality (GCDWQ)* for both aesthetic objectives and maximum allowable concentration, and for increasingly stringent guidelines that are likely to be implemented in the near future such as the US EPA's Regulations. The following guidelines will be followed for the Comox Water Treatment Plant:

- Ten State Standards;
- US EPA Filter Backwash Recycle Rule;
- US EPA UVDGM;
- US EPA Stage 2 Disinfection by-product rules stage 1; and
- US EPA Surface Water Treatment Rule.

Table 7-1 below describes the key treatment objectives for the Comox Water Treatment Plant.

Table 7-1: Treatment Objectives

Parameter	Objective	Source
Disinfection By-Products		
Total Trihalomethanes (mg/L)	< 0.08	EPA
Haloacetic Acids (mg/L)	<0.06	EPA
Metals		
Iron (mg/L)	< 0.30	GCDWQ
Manganese (mg/L)	< 0.05	GCDWQ
Corrosion Control		
Alkalinity (mg/L) as $CaCO_3$	> 10.0	
pH	7.0 to 8.5	
Organics		
Treated Water UVT	>94%	for optimal UV disinfection, see pilot data
TOC (mg/L)	< 1.0	for disinfection DBP reduction
DOC (mg/L)	< 1.0	for disinfection DBP reduction
Colour (TCU)	< 15	GCDWQ
Filter Performance		
Turbidity (NTU)	< 0.3 Direct Filtration [b] < 0.1 Membrane Filtration [a]	GCDWQ GCDWQ
Aluminum (mg/L)	< 0.2	GCDWQ

Notes:
a) At least 99% of measurements per operational filter period or per month. Measurements greater than 0.1 NTU for a period greater than 15 minutes from an individual membrane unit should immediately trigger investigation of the membrane integrity
b) In at least 95% of measurements either per filter cycle or per month; never to exceed 1.0 NTU

7.3 Plant Inlet Flow Control Philosophy

Flow control of the raw water to the WTP will be via the RWPS. Plant flow rate will be an operator selected value based on historical flow rate for that day (e.g. average of a 3 day window) the previous year, adjust as required to account for weekdays versus weekends, water restrictions or other factors. The daily selected value will then be trimmed by the plant control system (to a setpoint maximum percent) based on clearwell level.

The plant inlet will include an emergency isolation valve and flow split to two downstream process trains.

7.4 Plant Hydraulics

Plant hydraulics are dictated by the existing CVRD distribution system established by the BC Hydro Puntledge Diversion Dam having elevation of 130.15 m (PDR 2016 – TM.3, Section 2.2). Matching this elevation as the delivery head to the tie-in point is a primary governing design criteria and is the reason for the establish clearwell elevation.

Direct Filtration

Flow from the plant inlet to the clearwell is by gravity. The backwash system is the only part of the direct filtration that is pumped.

Pressurized Membrane

Flow from the plant inlet to the flocculation tanks is by gravity. From the floc tank, the water is pumped through the pressure membranes, and to the clearwell.

Submerged Membrane

Flow from plant inlet to the membrane tanks is by gravity. Water is pumped through the membranes, into the clearwell to overcome the headloss across the membranes.

Table 7-2 summarizes the hydraulics for the three filtration options:

Table 7-2: Plant Hydraulic Comparison

Filtration Option	Net Headloss (M)	Type
Direct Filtration	Gravity	8.0
Pressure Membrane	In Plant Pumping	24.8
Submerged Membrane	In Plant Pumping	15.0

7.5 Pre-Treatment

Water treatment chemicals are added to the raw water with hydraulic in-pipe flash mixing applied using pumps. Table 7-3 summarizes the design criteria for pump mixing.

Table 7-3: Flash Mix Sizing

DESCRIPTION	CRITERIA		
	75 ML/D	**90 ML/D**	**120 ML/D**
Flash Mix			
Type:		Pump Diffusion	
Number of pumps (one standby)		2	
Mixing Energy, sec^{-1}		750 – 1000	
Pump Capacity (each), L/sec		20	
Pump Motor Size, hp		15	

Selection of aluminum based coagulant for enhanced TOC removal and moderate impact on pH and alkalinity is based on data from the Pilot Study (Appendix F), which showed coagulant dosages in a range of 7 mg/L to 10 mg/L provide optimal floc formation and increase in UVT. Table 7-4 summarizes the chemical system.

Table 7-4: Coagulant System Criteria

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Coagulant			
Chemical		Poly-aluminum chloride	
Concentration, percent		17.1	
Specific Gravity, mg/mL		1.24	
Storage			
No. of Tanks	2	2	3
Capacity (each), litres	15,000	15,000	15,000
Capacity (total), litres [b]	30,000	30,000	45,000
Coagulant Dose			
Target Dose, mg/L		4 to 8	
Maximum Feed Rate, L/hr	120	144	190
Average Feed Rate [a], L/hr	41	55	76
Feeders			
No (1 standby)		3	
Turndown Ratio		20	

Notes:
a) At 7 mg/L dose and average conditions.
b) Maximum of maximum feed at 7 days or average feed at 21 days.

Coagulant aid polymers were evaluated during the Pilot Testing. It was found that there was limited improvement in floc formation with the use of a coagulant aid polymer during low turbidity conditions (0.39 NTU). However, coagulant aid polymer can improve organic removal during full-scale filtration and speed up the rate of coagulation in cold water. During the piloting, the water was in the range of 10 to 13 ºC and it took the full 20 minutes of mixing for floc formation during the flow turbidity tests. Therefore, the building will be sized to provide provision for coagulant aid polymer totes and dosing system.

Table 7-5 provides the design criteria for a coagulant aid polymer including the feed rates to be used for the basis of reserving building footprint for future addition of a coagulant aid system.

Table 7-5: Design Criteria for Coagulant Aid Polymer

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Coagulant			
Chemical		Cationic Polymer	
Concentration, %		50	
Specific Gravity		1.4	
Storage			
No. of Tanks	2	2	3
Capacity (total), litres	3,000	3,000	3,000
Total Capacity, litres	6,000	6,000	9,000
Chemical Dose			
Target Dose, mg/L		0.1 to 2	
Maximum Feed Rate, L/hr	9.0	10.8	14.4
Average Feed Rate [a], L/hr	1.8	2.4	3.3
Feeders			
Minimum Feed Rate (each), L/hr	0.5	1.0	1.0
Turndown Capacity		20:1	
No. of feeders	2	2	2

Notes:
a) At 1.0 mg/L

7.6 Flocculation

Three flocculation basins are proposed with planned expansion to six basins at build-out. The proposed floc basins consist of concrete rectangular structures compartmentalized into three stages divided by diffuser walls. Each stage is equipped with one vertical shaft, pitched-blade impellers that provide the mixing energy for flocculation. The final stage for direct filtration is not equipped with an impeller.

The mixing energy or velocity gradient is tapered as the water passes through the three stages. Periodic maintenance will be required for removal of solids from the bottom of the floc basins depending on raw water quality and inlet flow rate. Removal of solids from floc basins is typically accommodated by shutdown and dewatering of each basin and hosing the solids to a sump.

Table 7-6 below provides a summary of the design criteria for the flocculation basins.

Table 7-6: **Flocculation System Criteria**

DESCRIPTION	CRITERIA		
	75 ML/D	**90 ML/D**	**120 ML/D**
Flocculation Basins			
Hydraulic Retention Time [1], min	17	18	21
Numbers of basins [2, 3], No.	3	4	6
Cell Dimensions, m x m	4.0 x 4.0	4.0 x 4.0	4.0 x 4.0
Water Depth, m		6	
Flocculation cells per basin, No.		3	
Flocculation Mixers			
Flocculators per cell (1st and 2nd only), No.	1	1	1
Total number of flocculators, No.	6	8	12
Drive Type		VFD	
Motor size (Stage 1 & 2)	1.5, 1	1.5, 1	1.5, 1
Velocity Gradient "G" (Stage 1, 2 & 3)	60, 30, 0	60, 30, 0	60, 30, 0

Notes:
1. HRT of 20 minutes during winter and 15 minutes during summer
2. During "turn-down" of 15 ML/day only 1 basin would be in operation, resulting in an HRT of 28 minutes. VFD flocculator motors are provided to allow for adjustment of the velocity gradient to optimize treatment.
3. During ADD at 33 ML/day an HRT of 25 minutes and 13 minutes would result of 2 and 1 basin operation, respectively.

7.7 Direct Filtration Option

Direct filtration would be used to achieve the following water treatment goals as described in Table 7-5.

Table 7-7: Direct Filtration Log Removal by Treatment Unit

CRITERIA	LOG REMOVAL			
	FILTER	**UV**	**CHLORINE**	***TOTAL***
Giardia	2.5	0.5	0.5	*3.5*
Cryptosporidium	2.5	0.5	0	*3*
Viruses	1		3	*4*
Turbidity (NTU)	< 0.3			

Note that available *Cryptosporidium* and *Giardia* records for Comox Lake suggest that the water would fall into Bin 1 of the US EPA's Long-Term 2 Enhanced Surface Water Treatment Rule (LT2). The stage one design criterion for filters is the loading rate. A maximum loading rate summery MDD was selected as 15 meters/hour. Filters must be periodically backwashed to remove the floc particulate that accumulates on the filters over time.

Backwashing typically occurs when the headloss across the filters becomes too high, or if the filters breakthrough in terms of turbidity as detected through on-line turbidity analyzers. When a filter is backwashed, it is first taken off-line, the filter is then drained. Air scouring is then applied through the filter media to loosen more concentrated debris through the filter media. Table 7-6 presents the design criteria for the filters. The number of filters was changed from TM-2 because of the typical high quality water and a lower design flow.

Table 7-8: Rapid Sand Filter Design Summary

DESCRIPTION	CRITERIA		
	75 ML/DAY	90 ML/DAY	120 ML/DAY
Filter			
Type:	Dual media		
Number of Filters (1, 2), No.	6[a,b]	7[a,b]	8[a,b]
Cells per Filter	1		
Size of Cell (W x L), m (ft) x m (ft)	5.49 (18) x 8.53 (28)		
Media Area per Filter, m^2	50.2		
Filtration Rate: One out of Service, m/hr	12.5	12.5	14.2
Filter Media			
Anthracite			
Depth, m	1.2		
Effective Size, mm	1.35 to 1.4		
Sand			
Depth, m	0.3		
Effective Size, mm	0.5		
Total Depth, m	1.5		
Total L/d	1,460 [c]		
Filter to Waste			
Design Rate, m/hr	12		
Anticipated Duration, min	5 to 10		
Anticipated Volume m^3	50 to 100		
Filter Backwash System			
Type	Pumped backwash with air scour		
Backwash loading rate (max), m/hr	50		
Backwash duration (typical water wash), min	10 to 20		
Number of pumps, No.	3		
Brake Horsepower, ea, hp	75		
Air scour rate (3 minute duration assumed), Nm^3/min	40		
Number of blowers, No.	2		
Blower brake horsepower, ea. Hp	100		
Design Volume per backwash, m^3	420		

Notes:
a) During "turn-down" of 15 ML/day only 2 filters would need to be in operation, resulting in a filtration rate of 6.25 m/h.
b) During ADD of 33 ML/day only 3 filters would be need to be in operation, resulting in a filtration rate of 9.2 m/h.
c) L/d is a ratio of the depth of the filter bed (L) and size of the filter media (d). For coarse, deep filter beds the target range is 1,200 – 1,500.

The flow into the common filter inlet channel will be controlled by an automated butterfly valve. The channel will be tapered for even flow splitting to all of the filters. The level indicator on the filter will modulate the filter effluent control valve. As the pressure head builds on the filter media the effluent valve will open to maintain the filter throughput.

A low dose filter aid polymer, in the range of 0.01 to 0.05 mg/L has been shown to shorten the filter ripening times. In low turbidity sources, the filter ripening time can be quite lengthy, as found in the piloting work; the filter ripening typically took over an hour. The filter aid polymer will act to bind the filter media together which would happen naturally in a more turbid water source.

The filter aid polymer will be dosed into each filter feed channel with an individual feed system for each filter. The filter aid polymer will be dispersed their through a static mixer or through injecting the filter aid polymer at the turbulent inlet to the filters. Table 7-9 describes the design criteria for the filter aid polymer including the feed rates.

Table 7-9: Design Criteria for Filter Aid Polymer

DESCRIPTION	CRITERIA		
	75 ML/D	**90 ML/D**	**120 ML/D**
Chemical	High molecular weight non-ionic Polymer		
Neat Concentration, %	50%		
Day Tank Concentration, %	1%		
Specific Gravity, neat / day tank	1.4 / 1.0		
Storage			
Type	20 Litre buckets		
Day Tank Capacity (total), litres	1,200	1,200	1,200
Chemical Dose			
Target Dose, mg/L	0.01 to 0.05		
Maximum Feed Rate, L/hr/filter	3.1	3.1	3.2
Average Feed Rate, L/hr/filter	0.25	0.25	0.25
Feeders			
Capacity, L/hr	3		
Turndown Ratio	12:1		
No. pumps (per filter)	1 (1 standby per 3 duty pumps)		
Total No. Feeder	8	9	10

7.8 Membrane Filtration Option

Membrane filtration physically removes turbidity and other particulate matters under a hydraulic pressure gradient through microscopic pores. The systems are typically capable of up to 4-log removal of colloids, protozoa and viruses in a single process stage.

Membrane integrity (damaged membrane surface layer) and the pore size distribution play a greater role in the rejection of protozoa. The effectiveness to which the membrane is rejecting protozoa is expressed as log reduction value (LRV), which can be monitored by a membrane integrity test (MIT). MIT measures the rate of air leakage at a pressure that will pass through a 3,000 nm or larger wetted pore. Both pressurized and submerged operation configurations are considered in the indicative design. In pressurized ultrafiltration membrane systems, membranes are arranged in racks and water is pumped through filter modules. In submerged membranes, the membranes are submerged in open tanks and water is drawn through the filters using vacuum generated pump suction.

Table 7-10 presents the treatment goals for the membrane treatment options.

Table 7-10: Treatment Goals for the Membrane Treatment Options

CRITERIA	LOG REMOVAL		
	MEMBRANE	CHLORINE	*TOTAL*
Giardia	>3	1	*>4*
Cryptosporidium	>3	0	*>3*
Viruses	-	4	*4*
Turbidity (NTU)	≤0.1		

In achieving the above goals, the following membrane configurations and parameters are considered for the indicative design of the membrane treatment options:

Geometry. Only hollow-fibre membrane operations are considered in the indicative design due to its superior packing density and backwash ability compared to other membrane counterparts, such as tubular and flat sheet.

Pore Size and Material. Only microfiltration and ultrafiltration membranes with pores that are orders of magnitude smaller than Crytosporidium oocysts and Giardia cysts are considered for treatment efficacy. Polyvinyldene Fluoride (PVDF) and Polyethersulfone (PES) are considered for the indicative design as the acceptable membrane material. PVDF is understood to be stronger and has higher tolerance to chlorine membrane cleaning solutions compared to PES. However, PES has higher resistance to high pH chemical cleaning which tends to be more effective at removing organic fouling than does chlorine. It also tends to have smaller nominal pore size and tighter pore size distribution, providing greater reduction of pathogens.

Flow Path. Both outside-in and inside-out filtration paths are considered in the indicative design. In the outside-in operation, raw water is permeated through the membrane to the inside (lumen) of the hollow fibre, and vice versa with the inside-out operation. Typically, the outside-in path membranes are able to handle larger particle sizes and higher solids concentration in the raw water than inside-out membranes. It also affords greater membrane surface area than the inside-out membranes.

Table 7-11 lists approved membrane manufacturers and systems. Other system integrators, such as H20 Innovations, Wigen, and Westech, may be considered provided similar application capability and experience is demonstrated (i.e. providing similar or larger capacity plant, for surface water treatment, to municipal potable water quality).

Table 7-11: Membrane Manufacturers and Characteristics

Flow Path	Material	Manufacturer	Pore Size (nm)	OD X ID (mm)
Pressurized				
Outside-In	PVDF	GE zw1500	20	1.1 x 0.66
		Pall aria	100	1.3 x 0.7
		Evoqua cp	40	1.03 x 0.54
		Hydranautics hydracap	80	1.2 x 0.6
		DOW integraflux	30	1.3 x 0.7
		Toray torayfil hfu	20	1.5 x 0.9
Inside-Out	PES	PENTAIRE NORRIT X-flow	20	1.2 x 0.8
		BASF inge DIZZER	20	4 x 0.9
		3m liqui-flux	10	1.2 x 0.8
Submerged				
Outside-In	PVDF	Ge zw1000	20	0.8 x 0.47
		Evoqua cs	40	1.03 x 0.54
		Toray torayfil hsu	20	1.5 x 0.9

In the case of Comox Lake water, colour and organics have historically not been an issue. However, chemical pre-treatment through coagulation and flocculation is included based on data from pilot program.

Membrane treatment will be conducted in 2 stages. The stage 1 membrane units will filter the supply raw water by separating the clean filtered water from the concentrated back pulse water. The stage 1 reject (back pulse waste stream) water will go to the stage 2 membrane units to be further concentrated by recovering additional filtered water. Subsequently, the achievable overall recovery is over 99.0 percent.

For both the pressurized and the submerged membrane treatment systems, variability in treated water demand will be met by adjusting the number of membrane trains, which are in operation. To achieve a turndown ratio, some (or all) of the membrane trains can be stopped and put into standby. The operation of the membrane trains is a semi-continuous process whereby each train is individually stopped and back pulsed for 30 to 60 seconds every 20 minutes to 1 hour. During times of low flow demand, the trains can be held in standby after their backpulse sequence. In addition, each train can have its individual flow rate modulated to reduce filtered water production. Table 7-11 and Table 7-12 present the indicative design for the pressurized and submerged configurations. Pre-treatment and flocculation are the same as direct filtration.

Table 7-12: Pressurized Membrane Filtration

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Stage 1			
Feed Pumps, No. x Power ea., kw	6 x 112	6 x 112	9 x 112
Auto B/W Strainers, No. x Power ea., kw	6 x 0.75	6 x 0.75	9 x 0.75
Membrane Trains, No.	6	6	9
Membrane Modules/Train, No. Initial (Maximum)		170 (192)	
Membranes Area/Module, m^2		56	
Air-Scour Blowers, No. x Power ea., kw		2 x 19	
Backpulse Pumps, No. x Power ea., kw		3 x 56	
B/W Equalization Tank, No. x Size, m^3		1 x 100	
Stage 2			
Membrane Feed Pumps, No. x Power ea., kw	3 x 22	3 x 22	4 x 22
Strainers, No.	3	3	4
Membrane Trains, No.	3	3	4
Membrane Modules/Train, No. Initial (Maximum)		60 (96)	
Membrane Area/Module, m^2		56	
Air-Scour Blowers, No. x Power ea., kw		2 x 3.7	
Backpulse Pumps, No. x Power ea., kw	3 x 15	3 x 15	4 x 15
Back Pulse Equalization Tank, No. x Size, m^3		1 x 40	
Backpulse Waste Pumps, No. x Power ea., kw	2 x 3.7	2 x 3.7	3 x 3.7
Utilities			
Instrument/MIT Air Compressors, No. x Power ea., kw		2 x 3.7	

Table 7-13: Submerged Membrane Filters

DESCRIPTION	CRITERIA		
	75 ML/D	**90 ML/D**	**120 ML/D**
Stage 1			
Feed Water Channel, No. x Size, m^3	1 x 50	1 x 50	1 x 80
Membrane Tanks, No. x Size ea., m^3	5 x 50		8 x 50
Permeate Pumps, No. x Power ea., kw	5 x 37	5 x 37	8 x 37
Membrane Trains, No.	5	5	8
Membranes Modules/Train, No. Initial (Maximum)		261 (288)	
Membranes Area/Module, m^2		51	
Air-Scour Blowers, No. x Power ea., kw		2 x 19	
Backpulse Pumps, No. x Power ea., kw		3 x 30	
Back Pulse Equalization Tank, No. x Size, m^3		1 x 100	
Backpulse Waste Pumps, No. x Power ea., kw	3 x 7.5	3 x 7.5	4 x 7.5
Stage 2			
Feed Water Channel, No. x Size, m^3	1 x 24	1 x 24	1 x 32
Membrane Tanks, No. x Size ea., m^3	3 x 16	3 x 16	4 x 16
Permeate Pumps, No. x Power ea., kw	3 x 7.5	3 x 7.5	4 x 7.5
Membrane Trains, No.	3	3	4
Membrane Modules/Train, No. Initial (Maximum)		80 (96)	
Membrane Area/Module, m^2		51	
Air-Scour Blowers, No. x Power ea., kw		2 x 3.7	
Backpulse Pumps, No. x Power ea., kw		3 x 7.5	
Backpulse Equalization Tank, No. x Size, m^3		1 x 40	
Backpulse Waste Pumps, No. x Power ea., kw	2 x 3.7	2 x 3.7	3 x 3.7
Utilities			
Instrument/MIT Air Compressors, No. x Power ea., kw		2 x 3.7	

7.8.1 Membrane System Design Flux

The membrane flux is a measure of the filtration rate of water through the membranes and is expressed in units of Litres/hour of water flow per m^2 of membrane surface area (abbreviated as LMH). The design flux is an important factor to consider because it represents a trade-off between lower capital cost vs lower operating cost. At a higher (more aggressive) design flux, the plant design will have lower capital cost because it will require fewer membranes and consequently require a smaller plant 'foot-print' size. However, a low (more conservative) design flux will result in lower operating pressure (and thus lower power consumption) as well as less membrane fouling and cleaning frequency.

For the indicative design of membrane treatment, the maximum design flux listed in Table 7-13 shall apply to each for the listed membrane technologies. Note: that the design flux refers to the resulting membrane average flux when all the membrane units are fully populated with membrane modules and the plant's rated design capacity. Differences in the allowable maximum design flux between the different membrane technologies have been applied to provide conservative values commonly used for this type of application.

Table 7-13: Membrane Systems Design Flux

FLOW PATH	MATERIAL	DESIGN FLUX
Pressurized		
Outside-In	PVDF	60 LMH – Stage 1 Membranes 35 LMH – Stage 2 Membranes
Inside-Out	PES	75 LMH – Stage 1 Membranes 40 LMH – Stage 2 Membranes
Submerged		
Outside-In	PVDF	50 LMH – Stage 1 Membranes 35 LMH – Stage 2 Membranes

7.8.2 Reject Water Recovery and Stage 2 Treatment of Residuals

First stage membrane reject will flow to an equalization tank that is also the feed tank to the stage 2 membrane units. The feed rate for the second stage (either pressurized or submerged options) should have sufficient capacity to allow for stage 1 membranes operation at 90% recovery during peak turbidity event or for pre-coagulation to remove organics.

The treated water from stage 2 will be treateded with UV lamps (1 duty and 1 standby) prior to the clearwell. The reject from the 2nd stage treatment is directed to and stored in a 30 m^3 backwash equalization tank for residual handling discussed in Section 7.10.

7.8.3 Clean-in-Place (CIP) and Neutralization

A CIP system for membrane systems to provide in-situ chemical cleaning using sodium hypochlorite and an acid (either citric, sulfuric, hydrochloric acid) or caustic solution. High pH, or hypochlorite, or both, cleaning is performed to remove organic matter trapped on the membrane surface.

Low pH cleans are typically conducted to remove mineral scales or metal oxides/hydroxides that may also be found in the raw water. The CIP waste from the stage one and stage two membrane systems is then neutralized in a neutralization tank prior to final disposal. The CIP system is summarized in Table 7-14.

Table 7-14: Pressurized Membrane Filtration

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Cleaning System			
CIP Tank, No. x Size, m^3		1 x 40	
Neutralization Tank, No. x Size, m^3		1 x 80	
CIP Tank Heater, No. x Power ea., kw		1 x 200	
CIP Pumps, No. x Power ea., kw		2 x 7.5	
Maintenance clean frequency (assumed)		1 time per week	
Recovery clean frequency (assumed)		6 times per year	

7.9 Primary Disinfection

For the direct filtration option, UV provides the additional 0.5 log inactivation post filtration that is required to achieve the 3-log inactivation of *Giardia* and *Cryptosporidium* treatment objective. A 2.0-log inactivation capacity is selected for this design to provide additional safeguard in the event of a turbidity breakthrough. In such an event, all UV reactors would be applied to full power for maximum inactivation. At this sizing, the UV facility would be able to provide 3-log activation for most of the low flow periods during which turbidity has historically occurred. The following Table 7-15 summarizes the design criteria. A low pressure high output (LPHO) or medium pressure (MP) type UV system will be permitted for the direct filtration option.

Table 7-15: UV Disinfection Criteria for Direct Filtration

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Required Disinfection	0.5-log *Giardia* and *Cryptosporidium*		
Design Inactivation Target	2.0-log *Giardia* and *Cryptosporidium*		
Minimum Dose, mJ/cm^2	5.8		
Design UVT, percent	93		
Design (maximum) flow per reactor, ML/day	45		
Maximum headloss at max flow, mm	400		
Minimum Flow, ML/day	15	15	15
Number of reactors, no. (duty/standby)	3 (2/1)	3 (2/1)	4 (3/1)
Lamp Type	LPHO or MP		

For both membrane options, *Giardia* and *Cryptosporidium* is removed by the membrane pores. A LPHO UV system is also selected to provide additional safeguard for treatment of the stage 2 membrane permeate prior to blending with the Stage 1 permeate. This approach is used at City of Nanaimo's South Fork WTP and is therefore anticipated to be required by VIHA. Disinfection Criteria for Membrane Filtration Options is shown in Table 7-16.

Table 7-16: Disinfection Criteria for Membrane Filtration Options

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Required Disinfection	N/A		
Normal Target Disinfection	N/A		
Design Dose, mJ/cm^2	12.0		
Design UVT, percent	98		
Maximum headloss at max flow, mm	600		
Minimum Flow, ML/day	7.5	9	12
Number of reactors (1 standby)	2	2	3
Lamp Type	LPHO		

7.10 Chlorination

Chlorine provides primary disinfection for virus and residual chlorine for secondary disinfection. Under the membrane options, it also provides chlorine solution for membrane cleaning (CIP). The hypochlorite system will include the chemical fees system and the following other components:

- Bulk delivery fill station with control panel and spill containment pad sized for an entire chemical delivery truck.
- Storage tanks complete with secondary containment, fill and supply piping headers, overflow, drains, operator access to top and interior of tank, and redundant level instrumentation.

Capacity of bulk chemical trucks range from 10,000 litres to 20,000. Peristaltic metering pumps meter the 12.5% solution into the filtered water. Table 7-17 describes the design criteria for the bulk sodium hypochlorite system.

Table 7-17: Bulk Sodium Hypochlorite Design Criteria

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Storage			
Concentration, %		12.5	
Specific Gravity		1.17	
Number of Storage Tanks, No.	2	2	3
Capacity (each), L		7,500	
Capacity (total) [a], L	15,000	15,000	22,500
Design Chemical Dose Range			
Finished Water, mg/L		1.5 – 2.0	
Max Feed rate (at 1.8 mg/L), kg/hr	5.63	6.75	9.00
Min Feed rate (Winter at 1.5 mg/L), L/hr	6.4	7.7	10
Max Feed rate (MDD at 1.8 mg/L), L/hr	39	47	62
Feeders			
Number, total (duty / standby)		3 (2 / 1)	
Minimum Capacity (each), L/hr		6	
Footprint, m^2		100	

Notes:
a) Solution storage is based on 30 days storage at annual average flow rate in 50 year design horizon. If a membrane option is selected, the storage volume must be increased to account for chlorine usage with membrane CIP cleaning.

A memo comparing bulk hypochlorite delivery and storage as 12.5 percent solution versus on-site hypochlorite generation (OSHG) was prepared for review by CVRD and a final decision has not been made. OSHG addresses the concern of transporting 12.5% strength hypochlorite solution to Vancouver Island, but is approximately twice the capital cost and 50% higher cost as total lifecycle.

For flexibility, the chlorination system will be based on bulk-hypochlorite but the WTP facility will be configured to permit conversion to OSHG either in the future or upon selection by the DB proponent. Therefore, provision will be provided in the building footprint for conversion to OSHG. OSHG requires delivery of high purity salt and the use of an electrolytic cell to produce 0.8% sodium hypochlorite.

Table 7-18 describes the design criteria for the on-site hypochlorite generation.

Table 7-18: On-Site Hypochlorite Generation Provisional Design Criteria

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Storage			
Concentration, %		0.8	
Specific Gravity		1.0	
Number of Tanks, No.	2	2	3
Capacity (each), L	20,000	20,000	20,000
Capacity (total) [a], L	40,000	40,000	60,000
No. hours at peak dose, hrs[1]	57	47	53
Design Chemical Dose Range			
Finished Water, mg/L		1.5 – 2.0	
Feed rate (at 1.8 mg/L), kg/hr	5.6	7	9
Feed rate (at 1.8 mg/L), L/hr	703	844	1125
Feeders			
Number (1 standby)	4	4	6
Capacity (each), L/hr		250	
Footprint, m^2		250	

Notes:

a) Solution storage is based on 2 days storage at maximum day demand for 50 year design horizon. If a membrane option is selected, the storage volume must be increased to account for chlorine usage with membrane CIP cleaning. Storage of salt in saturator would be based on 30 days.

7.11 Clearwell

A clearwell will be included on the WTP site to provide chlorine contact time for virus disinfection and balancing storage for the water treatment plant. Chlorine contact time is required for all filtration options to achieve a target of 4-log virus reduction. However, it may be prudent to allow goals for minimum of CT corresponding to a 1-log *Giardia* disinfection target which is a more conservative contact time than 4-log virus. To achieve the required 0.7 baffle factor, there will be an inlet baffle and two baffle walls in each cell. Additionally, the conveyance from the clearwell to the tie-in at the existing chlorination building will provide additional contact time.

Table 7-19 described the criterion for the clearwell.

Table 7-19: CT Volume Requirements for Clearwell

DESCRIPTION	CRITERIA		
	75 ML/D	**90 ML/D**	**120 ML/D**
Minimum Water Temperature, ºC		2.0	
Target log removal, Giardia and Viruses		1-log *Giardia*, 4-log viruses	
CT, *Giardia*, mg/L min		50	
CT, Viruses, mg/L min		12	
Chlorine Residual, mg/L		1.4	
Baffle Factor		0.7	
Min. Chlorine Contact Volume for *Giardia* (pH 7.0) m^3	4,040	4,880	6,500
Min Chlorine Contact Volume for Viruses (pH 6.0), m^3	638	765	1,020

UV follows direction filtration to achieve the required log removal of *Giardia*. Therefore, sizing the clearwell for primary disinfection is based on 4.0-log virus. Provision to achieve 0.5 log *Giardia* inactivation is included in the balancince storage as a redundant barrier. The clearwell consists of two cells to facilitate maintenance and allow for isolation of one cell during low flow (winter) operation. A valve chamber will house the inlet, outlet and drain valves. A trench is provided in each cell for draining during maintenance or winter operation when only one cell is required. The floor is sloped towards the trench and small penetrations are provided along the base of each baffle wall to allow water to pass through. A duplex pump system is provided for draining the clearwell cells.

Under the ultimate design scenario, the clearwell configuration would be mirrored with the outlet, overflow, and drainage piping located at the centre of the two reservoirs to minimize pipe lengths and promote uniform hydraulic conditions. The clearwell provides not only chlorine contact time but also balancing storage for water treatment plant operations and distribution system balancing storage.

Table 7-20 presents the clearwell volume for WTP Operation.

Table 7-20: Clearwell Operating Volume

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Min. Chlorine Contact Volume for *Giardia* (pH 7.0) m^3	4,040	4,880	6,500
Balancing Storage (3 hours at MDD), m^3	9,375	11,250	15,000
Number of Cells	2	4	4
Volume Per Cell, m^3	5,000	5,000	5,000
Total Clearwell Volume, m^3	10,000	20,000	20,000

Future provision to double the clearwell size plus additional storage within the system will allow the CVWS to provide 20 ML total storage for the 90 and 120 ML/day design horizons.

7.12 Residual Treatment

Overall objective of the residuals treatment is to manage all treatment residuals on-site. CIP waste is covered in section 7.13. The membrane treatment system is expected to result in greater than 99% efficiency (using two stages). The direct filtration system is expected to result in 95% efficiency. The following section describes the residuals handling methods for both the direct filtration and the membrane system.

The residuals estimate accounts for turbidity solids, coagulant solids, and estimated filter runtimes. A 25% safety factor was applied to the estimate of solids and backwash volumes. Typically, the poor water quality coincides with low water use and the maximum flows have coincided with low turbidity. Seven scenarios were developed for sizing the residuals handling for the spent filter backwash water (SFBW). Table 7-21 describes the seven scenarios that have been used to design the direct filtration residuals handling units.

Table 7-21: Direct Filtration Residuals Handling Design Scenarios

Design Flow (ML/day)	Parameter	Design	Summer	Winter	Average	Min Solids	Max Solids	High Solids
75	Flow, ML/day	75	60	30	15	30	15	15
	Turbidity, NTU	0.3	0.5	3.3	0.8	0.4	15	9.5
	Solid, kg/day	413	353	409	116	171	534	379
	SFBW, m^3/day	1872	2080	1300	832	1248	2340	1560
90	Flow, ML/day	90	72	36	18	36	18	18
	Turbidity, NTU	0.3	0.5	3.3	0.8	0.4	15	9.5
	Solid, kg/day	496	424	491	139	205	640	455
	SFBW, m^3/day	2184	2496	1733	832	1248	3120	1560
120	Flow, ML/day	120	96	48	24	48	24	24
	Turbidity, NTU	0.3	0.5	3.3	0.8	0.4	15	9.5
	Solid, kg/day	662	565	655	185	274	854	606
	SFBW, m^3/day	2496	2912	1733	832	1664	3120	1560

The maximum solids scenario for the 75, 90 and 120 ML/day will be used to for the indicative design sizing of the residuals treatment system.

7.12.1 Direct Filtration Residuals Handling

Wastewater from the direct filtration plant is primarily the filter backwashes and the filter-to-waste during filter ripening. Optimizing filter performance can reduce the frequency of backwashes and thereby the volume of residuals produced. The onsite filter backwash water treatment consists of a high rate clarification stage; a thickening stage; followed by a centrifuge. The filter backwash will first be equalized for pumping to the spent filter backwash treatment system.

7.12.2 Backwash Equalization

The backwash equalization tanks will consist of 2 cells sized to receive at least four backwashes. A wet-well will allow pumping from either using submersible pumps. The submersible pumps will operate by VFD and run continuously to transfer backwash waste flow to backwash treatment.

Table 7-22 describes the sizing of the equalization tank and waste transfer pumps.

Table 7-22: Equalization Tank Sizing

DESCRIPTION	CRITERIA
Equalization Tank	
Size of cell, m, m	10 x 40
Depth of cell, m	2.5
Volume of cell, m^3	1,000
No. of Backwashes	5.7
Number of Cells	2
SFBW Pumping	
No. and Type of Pumps, total (duty/standby)	3 (2/1) submersible VFD
Pump Flow Rate (ea), m^3/day (US gpm)	800 to 1,250 (230)
Pump TDH, metres	15
Pump Motor Size, hp (kW)	7.5 (5.6)

7.12.3 Backwash Treatment

From the equalization tank, the SFBW will be pumped to high rate clarification and supernatant from clarification will flow by gravity to the head of the plant. The ballasted clarification consists of three flocculation tanks followed by a lamella sedimentation basin. A coagulant will be injected in the pipe before the first coagulation tank and allow dispersing in the first flocculation tank. In the second flocculation tank, microsand and flocculent aid polymer will be injected and mixed. The third flocculation tank allows time and mixing and for the maturation of the floc particles. Each of the flocculation tanks include a radial mixer.

The sedimentation basin will have lamella tubes to increase the effective settling area. Solids and microsand will be separated, and the solids will flow to the thickener.

Table 7-23: Backwash Treatment Design Criteria

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Ballasted Clarifier			
No. of Trains, total (duty/standby)	2 (1/1)	2 (1/1)	2 (1/1)
Capacity per unit, m^3/day		3,000	
Unit footprint, m^2		17	
Flow Recirculation, m^3/hour		4	
Assumed minimum percent solids capture, %		80	
Solids concentration of supernatant, mg/L		10	
Average Flow to thickener, m^3/day		77	
Sludge solids concentration, mg/L		1,500 to 5,000	
Mass rate to thickeners, kg/day		270 to 400	
No. Floc tanks per unit		3	
No. Microsand recirculation pumps per unit		2	

The settled solids from the backwash treatment will be pumped to a circular thickener through the center column. A baffle wall will dissipate the energy for quiescent settling conditions. A rotating skimmer arm with pickets will thicken and direct the thickened solids to a center hopper which are then pumped (in batch operation) to the centrifuge for the final dewatering stage. The effluent from the thickener will be directed to the SFBW equalization tank. Table 7-24 describes the sizing of the thickening equipment.

Table 7-24: Thickener Sizing for SFBW Treatment

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Thickener			
Design Hydraulic loading, m/hr (USgpm/sf)		0.3 (0.12)	
Design Mass Loading, kg/m^2/day (lbf/ft^2/day)		50 (10)	
Numbers of thickeners		2	
Diameter, m (ft)		4.0 (13.2)	
Surface area per thickener, m^2		12.57	
Hydraulic depth of thickener, m (ft)		4.5 (14.75)	
Wet volume in thickener, m^3		47	
Average supernatant flow, m^3/d	70	80	110
Average Volume of Sludge to Centrifuge, m^3/d	20	25	35
Storage, days		7	
Efficiency of removal, %		90	
Design solids to centrifuge, kg/d	480	560	745

The final dewatering stage is the centrifuge. The sludge from the thickener is fed into the centrifuge through the center feed inlet. The rotating force causes the solids to build up against the wall of the centrifuge bowl and the solids are pushed in opposite direction of the liquid by the screw conveyor. The water that has been separated (centrate) will be returned by gravity to the thickener. The solids produced (cake) will be stored in a bin or truck and hauled to a landfill for final disposal. Table 7-25 describes the design criteria for the dewatering.

Table 7-25: Centrifuge Design Criteria

DESCRIPTION	CRITERIA		
	75 ML/D	**90 ML/D**	**120 ML/D**
Centrifuge			
Number of units		1	
Hydraulic loading, m^3/hr		2 to 5	
Solids Recovery, %		95	
Dewatered Solids Content, %		20.0	
Solids Feed Concentration, %		2.0	
Polymer System			
Polymer Dose, kg per dry tonne		9	
Polymer Consumption, kg/d		4.5	

7.12.4 Membrane Filtration Residuals Handling

The membrane system will produce two waste streams, the backwash and the clean-in-place (CIP). The wastewater produced by the clean-in-place will be handled in its' own treatment system due to the high or low pH of the waste. Backpulse reject from the 2nd stage membrane will be pumped to the thickeners. Table 7-26 describes the water quality conditions for the membrane residuals sizing.

Table 7-26: Membrane Filtration Residuals Design Scenarios

Design Flow (ML/d)	Parameter	Design	Summer	Winter	Average	Min Solids	Max Solids	High Solids
75	Flow, ML/day	75	60	30	15	30	15	15
	Turbidity, NTU	0.3	0.5	3.3	0.8	0.4	15	9.5
	Total Solids, kg/day	136	131	223	41	60	441	286
	Total WW, m^3/day	409	338	160	71	169	71	71
90	Flow, ML/day	90	72	36	18	36	18	18
	Turbidity, NTU	0.3	0.5	3.3	0.8	0.4	15	9.5
	Total Solids, kg/day	163	158	268	50	72	529	343
	Total WW, m^3/day	498	410	195	88	205	88	88
120	Flow, ML/day	120	96	48	24	48	24	24
	Turbidity, NTU	0.3	0.5	3.3	0.8	0.4	15	9.5
	Total Solids, kg/day	218	210	357	66	96	705	458
	Total WW, m^3/day	677	552	267	124	276	124	124

The maximum solids scenario for the 75, 90 and 120 ML/day is used to size of the residuals treatment system. The membranes reject treatment system includes an equalization tank, gravity thickeners, and centrifuge. The backwash recycling is expected to recycle 99% of the backwash water. Seven scenarios were analyzed for sizing.

The gravity thickener will thicken the 2nd stage membrane reject. It operates in the same method as described the in SFBW treatment. The effluent from the thickener will be recycled to the head of the plant. Table 7-27 describes the thickener design.

Table 7-27 Thickener Sizing for Membrane Filtration

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Thickener			
Design Hydraulic loading, m/hr (USgpm/sf)		0.3 (0.12)	
Numbers of thickeners		2	
Diameter, m (ft)		4.8 (15.75)	
Surface area per thickener, m^2		18.10	
Hydraulic depth of thickener, m		4	
Wet volume in thickener, m^3		72	
Average Supernatant Flow, m^3/d	51	65	92
Average Volume of Sludge to Centrifuge, m^3/d	20	24	32
Storage, days	3 to 4	3 to 4	2 to 3
Design Efficiency of removal, %		90	
Design solids to centrifuge, kg/d	340	480	635

Final dewatering stage is the centrifuge. The sludge from the thickener is fed into the centrifuge through the center feed chamber. Table 7-28 describes the design criteria for the membrane reject treatment, were the centrifuge criteria matches Table 7-25.

Table 7-28: Membrane filtration residuals handling centrifuge design

DESCRIPTION	CRITERIA		
	75 ML/D	90 ML/D	120 ML/D
Centrifuge system – Table 7-25			
Polymer System			
Polymer Dose, kg/DT		9.0	
Polymer Consumption, kg/d	4	4	6.0
Polymer Flow, L/min	2.5	3.0	8
Run tank size, L	300	360	475
Centrate System – Table 7-25			

7.13 Clean-in-Place Treatment

The CIP wastewater from both Stage 1 and 2 membrane system will first be neutralized in a holding tank. Once neutralized, two management approaches were considered.

- Construct a waste pipeline to discharge the neutralized waste to City of Courtenay collection; or
- Construct engineered wetlands for treatment and infiltration to soil.

The former was informally denied by BC Hydro based on an alignment with the BC Hydro penstock property. The DB Proponent will need to coordinate with applicable authorities and regulators to obtain permits for any proposed waste disposal for discharge to sewer or to the environment. Spent membrane cleaning solutions will also need to be disposed of in a manner that will be acceptable to the local authorities. A constructed wetland with ground infiltration has been assumed for the purpose of indicative design for the flow discharges per Table 7-14.

8. Civil Works

8.1 Overview

This section establishes the basis of design for the civil works for the two sites, (WTP and the RWPS). The conveyance pipelines are detailed in the following section.

8.2 Applicable Codes and Standards

- AWWA C900
- Comox Valley Regional District Subdivision and Servicing Bylaw
- Fire Underwriters' Survey
- National Fire Protection Association
- MOE Guidelines for Design of Septic Systems
- TAC Geometric Design Guide for Canadian Roads, Most recent version
- Manual of Uniform Traffic Control Devices for Canada, Most recent version
- Sewerage System Standard Practice Manual Version 3, Ministry of Health, Health Protection Branch
- BC Hydro underground service requirements
- Canadian Electrical Code
- Master Municipal Construction Documents
- City of Courtenay DRAFT Subdivision and Servicing Bylaw
- Manual of Uniform Traffic Control Devices for Canada

8.3 WTP Site

8.3.1 Site Description

The proposed WTP site is located on Lake Trail Road, near the BC Hydro Diversion Dam and the Upper Puntledge fish hatchery. The parcel is being purchased by CVRD from Hancock Forest Management, its current owner. The site is irregularly shaped and is accessible from Lake Trail Road. It extends approximately 300 m away from Lake Trail Road, and is approximately 450 m wide parallel to Lake Trail Road. There is an unregistered heritage site setback near Lake Trail Road. Development is not allowed within the setback.

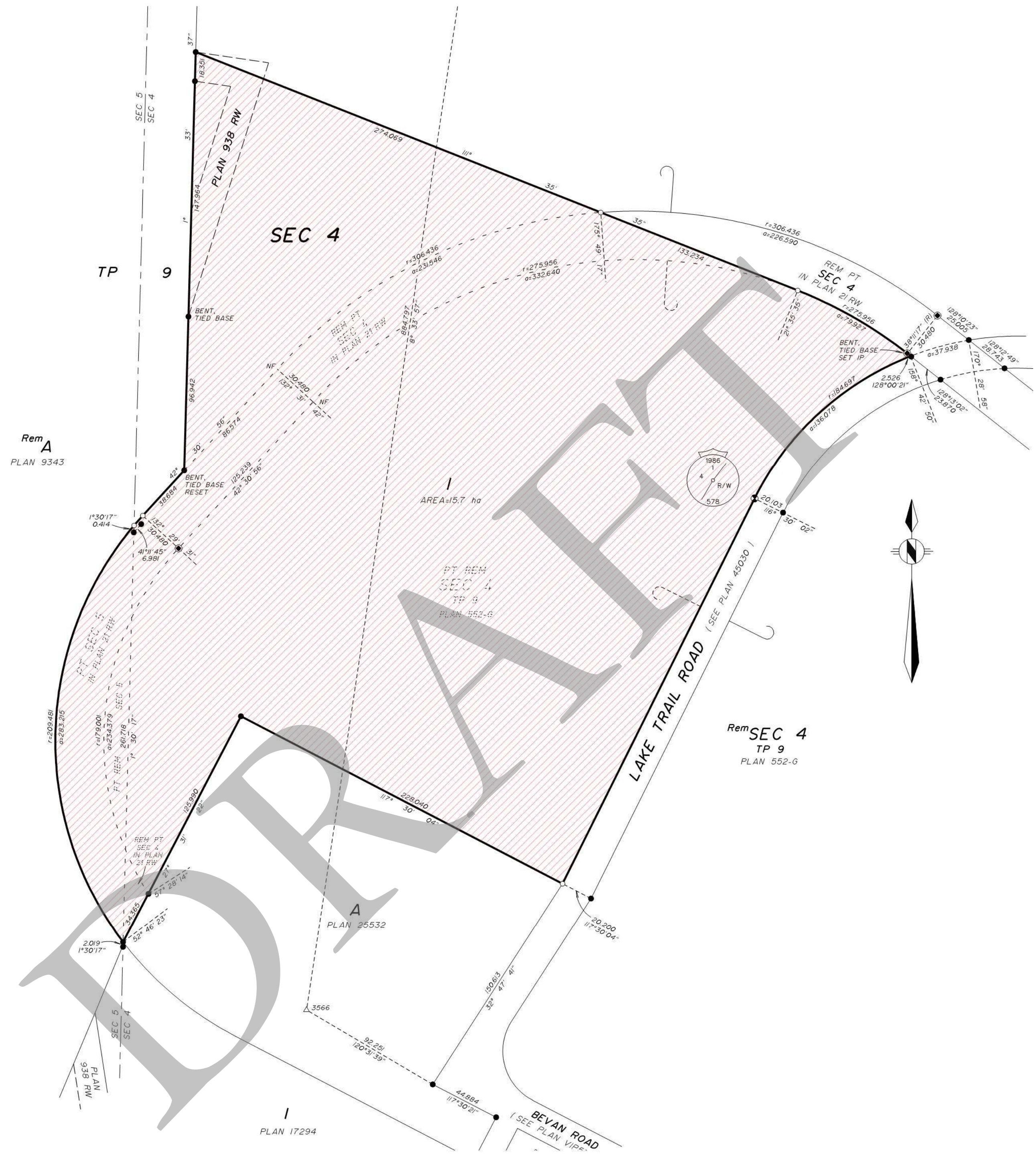

Figure 8-1: Property boundaries for WTP

8.3.2 Geotechnical Summary

One sonic borehole and two percolation tests were carried out at the WTP site. The borehole was drilled to a depth of 14.0 m near the southwest corner of the proposed WTP building. The two percolation tests were carried out at opposite ends of the site--the first near the southwest corner of the proposed WTP building, and the second at the southeast corner of the site, east of the proposed stormwater pond.

At the borehole location, the soil profile was SAND with trace to some silt to a depth of 2 m, and SILT from 2-8 m depth with clay content increasing with depth. There is a SAND and GRAVEL layer between 8-11 m depth, turning to SILTY SAND and GRAVEL below that point.

Excavations at the WTP site are expected to be up to 8 m depth. No soft or loose materials were encountered in the borehole above 8 m depth. Based on the preliminary geotechnical report, extensive dewatering is not anticipated at the WTP. Temporary slopes of 1H:1V are recommended for unsupported excavations.

Two permeability tests were carried out at the WTP. The tests were carried out within the sand layer near the surface. The percolation rates measured were as follows:

Test #	Test Location	Percolation Rate
PT17-01	Near SW corner of WTP Building	18 s / 25.4 mm
PT17-02	SE corner of site, east of stormwater pond	1m56s / 25.4 mm

Permanent slopes will not exceed 50%. Temporary slopes during construction will be established by the Proponent's geotechnical engineer. Slopes steeper than 33% will be required to incorporate slope armouring measures such as armouring mats to address erosion.

8.3.2.1 Bedrock / Blasting

No bedrock was encountered in the borehole at the WTP site, or at test pits TP17-08 and TP17-09 advanced near the site.

8.3.3 Site Development and Clearing

The proposed WTP site is a cleared forest block. The site slopes gently to the northeast at approximately 5%). Clearing and grubbing an area of approximately 24,000 m^2 is required prior to mass excavation to facilitate construction. The area will be stripped of topsoil prior to rough grading. Rough grading outside of building areas can be designed to achieve a quantity balance. The existing slope is adequate for roads, parking and loading areas once local high and low points are smoothed out through rough grading.

Approximately 26,000 m^3 of excavation is required for the flocculation basins, filters and clearwells.

8.3.4 Underground Site Services

The underground services at the WTP are illustrated on Drawing C-4001 and described below.

8.3.4.1 Stormwater

Stormwater will be managed by a system of overland flow and culverts. Roads will crossfall away from structures, and drain towards ditches, overland, or both as practical. Paved areas will drain directly overland where practical, and to ditches elsewhere. Overland flow will be captured by a swale leading to a stormwater retention pond. Culverts will be required across roadways at several locations.

A stormwater retention basin will be provided on the WTP site to attenuate flows to pre-development levels and is discussed in detail in the Stormwater Management subsection. Stormwater pipes and catchbasins may also be required to drain some paved areas.

8.3.4.2 Domestic Water

The potable water supply for the WTP and fireflows to protect the facility will be provided by a domestic water supply pumping system from the clearwell. The system will also supply water to a ring main that will follow the access road loop, sized to provide fire flows as described below.

8.3.4.3 Fire Protection

The RWPS and WTP are in the fire jurisdiction of Cumberland Fire Rescue. Currently, fire protection in the area is provided by bulk water as there are no hydrants.

MMCD Design Guidelines require a fire flow to be determined as follows:

- In accordance with the "Water Supply for Public Fire Protection - A Guide to Recommended Practice", published by Fire Underwriters Survey;
- A minimum of 150 L/s for institutional developments with sprinklers.

For the WTP, 150 L/s minimum is the greater of the two criteria and will apply.

The MMCD Design Guidelines requires that fire hydrants be located in general at street intersections and as follows:

- Not more than 150 m apart nor more than 90 m from a building.
- In accordance with "Water Supply for Public Fire Protection — A Guide to Recommended Practice", published by Fire Underwriters Survey.
- 2.0 m back from curb or 0.5 m back of sidewalk.
- Minimum 1.0 m clear of any other utility structure.
- At property lines in mid-block locations.

The 2012 British Columbia Building Code provides further guidelines for the maximum distance to buildings for hydrants (Division B, 3.2.5.5):

[Access routes shall be provided to a building so that] for a building not provided with a fire department connection, a fire department pumper vehicle can be located so that the length of the access route from a hydrant to the vehicle plus the unobstructed path of travel for the firefighter from the vehicle to the building is not more than 90 m.

The required pressure is determined as the greater of (a) 14 m, or (b) 7 m plus the head loss through the hydrant. The head loss through the hydrant is calculated as:

$$HL = 1{,}083 \times Q^2$$

Where: HL is head loss (m)
Q is fire flow (m^3/s)

For a flow of 150 L/s, the required pressure immediately upstream of a hydrant is 31.4 m (45 psi). A minimum of 2 hydrants supplied from the domestic ring watermain will be provided on-site.

A dedicated fire pump will be provided drawing from the clearwell to supply the ring watermain and hydrants.

8.3.4.4 Sanitary

A sanitary sewer will convey sanitary waste from the building to a septic field disposal system. The sewer will be sized for 10 L/s of flow at 50% full. A 150 mm ø pipe will likely be adequate.

8.3.4.5 Process Room Floor Drains

Drainage from the process floor drains will be directed to a series of infiltration manholes. The design infiltration capacity should be no less than 0.5 L/s of sustained flow and should be sized to allow storage of 1,200 L from regular eyewash/shower testing. An overflow from the infiltration system will be directed to the stormwater retention pond. The WTP building roof drains will also be piped to the infiltration system.

Calculation of design flows for the process drains will be determined by the designer based on full flow from all process area hose bibbs, washdown nozzles, emergency showers, roof drainage and other sources of floor drainage within the plant

8.3.4.6 Backwash Supply

A backwash supply pipe will convey clean water from the backwash pumping system at the clearwell to the filter backwash system at the WTP main building.

8.3.4.7 Spent Filter Backwash Effluent

A gravity pipe for backwash effluent will convey WTP spent backwash to the backwash waste equalization station.

8.3.4.8 Process Water Drainage

Water drained directly from treatment unit processes will be captured and recirculated to the head of the plant. The process drains will be directed to the backwash equalization station through a gravity pipe.

8.3.4.9 Equalized Backwash and Process Drainage

Spent backwash water and process drain water will be combined in the equalization station and pumped to the residuals treatment system through a pressurized pipe.

8.3.4.10 Overflow piping

Overflow piping from the coagulation/flocculation tanks, the filters, the clearwell, the backwash equalization tank and the residuals treatment system will be directed to a common overflow manhole which will discharge to the process overflow pond. Overflow piping will be sized based on full system capacity at maximum day demand flow (120 MLD). Overflow from the process overflow pond will be directed to the stormwater retention pond.

8.3.4.11 Underground Electrical Duct Banks

A set of buried conduits will carry power from the new BC Hydro overhead distribution lines to the unitized substation located at the main WTP building, near the electrical room. Individual buried conduits from the substation will provide power to ancillary structures including the clearwell, backwash equalization station and residuals treatment station.

8.3.4.12 Supply/distribution Watermains

Large diameter raw and treated watermains are described in detail in Section 9.

8.3.5 Vehicle Access, Roads, Parking

The main loop road around the treatment plant will accommodate a TAC WB-20 design vehicle for large equipment deliveries. For other secondary roads to the clearwell and accessory buildings, utility and fire trucks will require access.

Access road design will allow a WB-20 back-in access to both overhead doors at the WTP building for loading and unloading of equipment and supplies. Table 8-1 summarizes design parameters of the access and loop roads to the WTP location.

*Table 8-1: **Water Treatment Plant Road and Parking Area Design Parameters***

Design Parameter	WTP Site
Design Vehicle	WB-20 for main loop road around building Fire Truck for other roads within the site
Pavement Width (minimum)	Lane = 6 m Shoulder = 0.5 m Total width = 7 m
Design Speed (km/h)	30
Minimum Grade	1%
Maximum Grade	6%
Minimum Horizontal Curve	To accommodate the turning movements for the design vehicle
Minimum Turning Radii at Intersection	To meet design vehicle turning movements
Cross-slopes and Superelevation	Minimum - 2% Maximum – 3% Crown to be in centre of the pavement Superelevation not required
Minimum Utility Offset from Shoulder	1.5 m
Parking spaces	12 staff/visitor 1 accessible 2 loading zones
Minimum parking stall widths	3.0 m Accessible parking stall = 4.0 m
Pavement Structure	25-year service life Loading to suit design vehicle
Curb and gutter	Road will have gravel shoulders and drainage ditches where required.
Traffic signs	Manual of Uniform Traffic Control Devices for Canada, Latest Version
Pavement Markings	Manual of Uniform Traffic Control Devices for Canada, Latest Version
Pedestrian Facilities	Ramps for accessibility Pedestrian crossing near parking facility Sidewalks as required for pedestrian mobility

8.3.6 Domestic Sewage Septic System

8.3.6.1 General

Sanitary flows from the WTP will be managed by an on-site septic system. The design will adhere to the British Columbia Sewerage System Standard Practice Manual Version 3 (September 2014) (SPM), published by the Ministry of Health. The SPM provides standards and guidelines for site and soil evaluation, planning, installation and maintenance for sewerage systems under the Sewerage System Regulation (SSR).

The proponent will be responsible for providing an 'Authorized Person' (AP) to plan and design the system in accordance with the SPM, and to be responsible for the review of the installation. The AP shall provide an operations and maintenance manual and gain approval for the system by the Vancouver Island Health Authority (VIHA). The CVRD will be designated as the 'System Owner'.

The septic system consists of two components: treatment and discharge. The treatment section treats the effluent to an appropriate level before the effluent reaches the discharge area. It will be the responsibility of the AP to determine the appropriate level of treatment in accordance with the SPM and VIHA requirements.

Generally, the sensitivity of the receiving body dictates the required level of treatment, which will be either Type 1, Type 2, or Type 3, as defined in the SPM. The level of treatment, site conditions, and dispersal system type dictate the required size of the septic field.

8.3.6.2 Daily Design Flow (DDF)

On average, 10 full-time staff will occupy the main WTP building. On occasion, public tours will increase occupancy to around 20 persons. Flow to the septic system will originate from a lab and two washrooms with no showers.

For design purposes, Table III-11 of the SPM, based on an Office/Factory without a cafeteria, the design flow is 50-75 L/day/person. Based on the maximum occupancy of 20 persons, the DDF is 75 x 20 = 1,500 L/day.

This DDF does not include an allowance for a water and sewer service for parks users.

8.3.6.3 Pumping

A pumped septic system will be provided as a pressurized system improves dispersion of effluent, compared to most gravity systems, and also provides more flexibility for locating the field on the site.

8.3.6.4 Horizontal Separation (SPM Section II-5.4)

The SPM requires a minimum separation between the septic system components and nearby features vulnerable to contamination. Sensitive features include water sources, wells, watermains, buried reservoirs, cisterns and water bodies.

Minimum horizontal separation values are provided in SPM Table II-19.

8.3.6.5 Vertical Separation (SPM Section II-5.4)

Soil and groundwater conditions in the proposed septic field area will be evaluated by the Proponent to establish the limiting surface and to design adequate vertical separation.

8.3.7 Process Overflow Pond

Process waste streams will vary depending on the treatment approach.

Direct filtration will generate filter backwash water, which will be treated to remove solids and the liquid effluent would be re-introduced to the flocculation basins at the head of the treatment plant.

Membrane filtration will produce approximately a wastestream of 350 m3/day, at the ultimate system flows of 140 MLD, which contains chemicals from the Clean-in-Place system, and will require some form of treatment, or discharge to sewer through a new sewermain.

Treatment of residuals is described in detail in the Water Treatment Plant section.

8.3.8 Stormwater Management

8.3.8.1 Design Criteria

The post-development flow is to be attenuated to the pre-development peak flow. The table below summarizes the design parameters for site stormwater management.

Table 8-2: Stormwater Management Design Parameters

Design Parameter	Value	Criteria
Runoff Coefficients (Rational Method)		
Forested Areas	C=0.3	MMCD Design Guidelines
Impervious Areas	C=0.95	Best Practices
IDF Curve Gauge Location	Courtenay-Puntledge	City of Courtenay Draft Subdivision and Development Servicing Bylaw (SDSB)
Storm Distribution	SCS Type 1a	BC MoT
Minor system design basis	1:5 year storm	Courtenay Draft SDSB
Major system design basis	1:100 year storm	Courtenay Draft SDSB
Climate Change Factor (applied to post-development storm events)	15%	Courtenay Draft SDSB
Pre-Development Time of Concentration (t_c)	20 mins	SCS Curve Number Method (compared with Hathaway Formula and Bransby-Williams Method as a check).
Post-Development Time of Concentration (t_c)	5 mins	BC MoT based on residential development
WTP Site Stormwater Pond:		
Min depth	1.5 m	Courtenay Draft SDSB
Max depth	4.0m	Best Practices
Max sideslope	7H:1V	Courtenay Draft SDSB
Min catchment area	20 ha	Courtenay Draft SDSB

Based on the IDF supplied from Environment Canada, best-fit equations were developed based on the curve for each return-period. For 24 hour storm, 1:100 year return interval, the average rainfall is 7 mm/hr.

The WTP site was divided into two subcatchment areas and the following subcatchment and catchment criteria were calculated from the site survey and contours.

Table 8-3: Catchment Area Characteristics

Sub-catchment	Area			Length (m)		Slope (m/m)
WTP	m^2	km^2	Ha	Overland	Channel	
1	37,315	0.0374	3.74	270	0	0.033
2	16,901	0.0169	1.69	350	0	0.033
Total or maximum:	**54,216**	**0.0542**	**5.42**	**350**	**0**	**0.033**

8.3.8.2 Design Approach

The area is mostly made up of Quenell soils, which are generally sandy-loamy, with good drainage characteristics, as per BC Soil Information Finder Tool (SIFT). A Hydrological Soil Group (HSG) of A is generally applied. An Antecedent Moisture Condition (AMC) of Class III is applied for this area as well. Soil permeability rates are presented in Appendix B. From Table 1-3, the pre-development time of concentration (Tc) was taken to be 20 minutes and the post-development Tc is 5 minutes.

The 24-hour 1:100 year average rainfall intensity of 7 mm/hr was utilized to determine the total rainfall volume. The total volume was then distributed according to the SCS Type 1a storm in six minute intervals. Figure 8.2 below shows the Type 1a rainfall intensity distribution for the design event

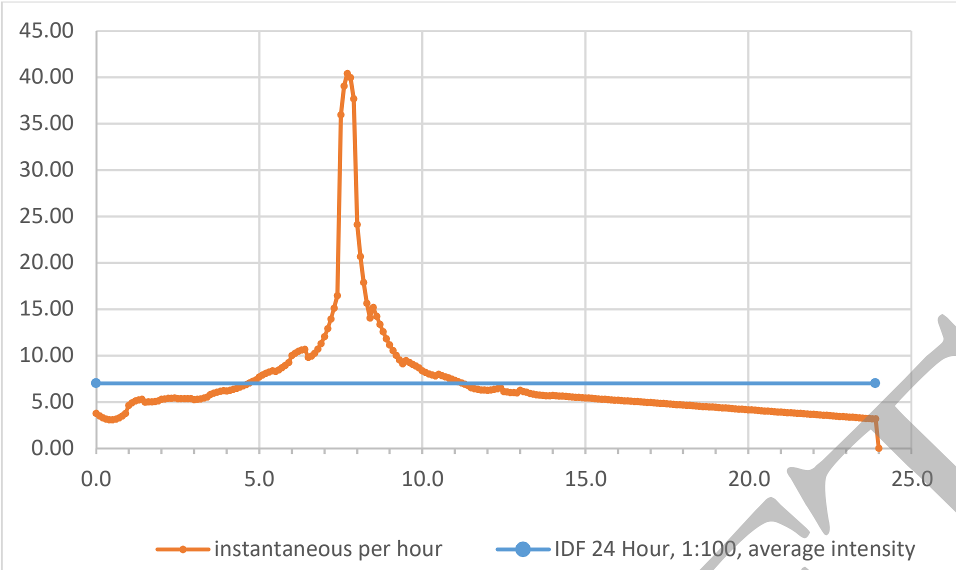

Figure 8-2: Design storm distribution

The maximum intensity was determined to be 40.44 mm/hr. Utilizing the Rational Formula and unit conversions:Q=CiA/360

C = 0.3, i = 40.44 mm/hr, A = 5.42 ha,

Q = 0.182 654 m3/s = 182.7 L/s

The anticipated post-development peak flow to be attenuated was calculated, with a time of concentration of 5 minutes (the BC MOT minimum) to be 1977 L/s. It is estimated that a 1:100 return period rainfall event storage of 1600 m3 is required for this attenuation.

8.3.8.3 WTP Stormwater Pond

A volume of 1600 m^3 is anticipated to be required to attenuate the 1:100 critical storm event. A stormwater pond is suggested for this role. A minimum 25 mm storm event for the catchment area is required to be stored in the permanent pool, below the normal water level. The permanent pool volume is to be at least 1400 m^3. The estimated time to drain shall be less than 40 hours, as suggested in the City of Courtenay DRAFT SDS bylaw.

8.3.9 Site Security

8.3.9.1 General

Overall site security is covered in detail in section 17. This subsection describes security items which are related to civil works.

8.3.9.2 Fencing

The perimeter fencing around the WTP will be an alarmed, powered electric fence. The fencing will either fully enclose the site, or will terminate on either side of the building entrance to allow access to the building without opening the access gate.

8.3.9.3 Gates

A motorized gate is to be provided at site entrance based on design vehicle requirements. The requirements are described in the Site Security section.

8.3.9.4 Site Lighting

Exterior lighting for the WTP site will have the capacity to illuminate parking areas, pedestrian paths and building entrances.

Outdoor lighting will have both automatic and manual controls. Automatic controls will use motion-sensors and photocells to control the lighting. A manual switch inside the station will allow users to override automatic mode and turn exterior lighting on or off manually.

8.3.9.5 Public Access Location

A portion of the site near the entrance to the WTP will be open to the public, for hikers and cyclists using the trail network in the area, as well as for tours of the WTP. Public areas will be separated from operational areas by fencing and security measures within the WTP building.

8.3.9.6 Bollards

Bollards will be fitted along the western perimeter fence line as indicated on the site plan, to prevent a vehicle from accidentally or maliciously breaching the perimeter fence line.

8.3.10 Integration with BC Hydro Trails

BC Hydro maintains a network of hiking/cycling trails along the Puntledge River. There is an existing trail from Lake Trail Road connecting to this trail network. A new public use trail will be constructed outside the fenced area of the WTP connecting to the trail network. The trail will be a gravel path approximately 1.2 m wide. Parking will be provided for trail users at the WTP.

8.3.11 Irrigation Methods

Most cleared areas on-site will be seeded with a low-maintenance, drought resistant native grass mix and will not require irrigation after establishment. Irrigation will be required around the main WTP building for plantings. The extent of plantings is expected to be limited to within 3 m of the building, away from doors and staging areas. Drip irrigation can be used for plantings from the pumped domestic water service from the clearwell.

8.3.12 Landscaping

Hardscaping is described in Section 11.6.5

8.3.13 Erosion and Sediment Control

Erosion and Sediment Control Plans (ESCPs) are anticipated to be required for the following:

- Runoff during construction
- Disposal of water after hydrostatic and pressure testing
- Disposal of superchlorinated water following disinfection activities for treated water piping
- Flushing and cleaning
- Dewatering excavations

Sediment control can be achieved using a settling pond sized for the anticipated flows.

8.4 Raw Water Pump Station

8.4.1 Site Description

The proposed Raw Water Pump Station (RWPS) is situated at the northeastern shoreline of Comox Lake, near the Comox Lake Dam which separates Comox Lake from the Puntledge River.

Minimum setback distances for structures are governed by 15 m riparian setback from the Comox Lake mean high water level (135.33 m geodetic elevation), and by the Probable Maximum Flood (PMF) elevation (139.90 m geodetic elevation). All structures will be situated above the PMF elevation. Encroachment within the 15 m riparian setback will be necessary, and will require environmental compensation measures to offset impacts. The Proponent’s team will be responsible for proposing compensation measures and obtaining approvals.

The site is serviced from the Comox Lake Logging Road, which is an active logging road used by TimberWest Forest Corporation and Hancock Forest Management.

The site will house the raw water pump station and wet well, a pad mounted BC Hydro transformer, and a pad mounted emergency generator in an enclosure. The proposed pump station wet well will be approximately 16 m deep. During construction, the wet well may also serve as an access point for installing the intake using trenchless methods.

8.4.2 Geotechnical Summary

The soils at the raw water pump station generally consist of the following based on a single borehole log at the pump station site:

- Fill to 2.1 m depth
- Sand to gravelly sand with boulders to a depth of 4.5m below grade
- Clayey sand and gravel to a depth of 16.7 m below grade

The groundwater level observed at the boreholes was approximately the same as the level of Comox Lake at the time. Based on the excavation depth and the soil conditions, it is likely that well point dewatering will be required for the pump station excavation. A dewatering plan will need to be developed to provide adequate pumping capacity, and for monitoring discharge to comply with environmental sediment control requirements. Treatment of groundwater prior to discharge may be required due to fine-grained soils which exist at depth.

8.4.2.1 Slopes

Permanent slopes should not exceed 50%. Temporary slopes during construction should be established by the Design team's geotechnical engineer. Slopes steeper than 33% will be required to incorporate slope armouring measures such as armouring mats to address erosion.

8.4.2.2 Bedrock / Blasting

Bedrock was encountered at the proposed RWPS site at an elevation of 121.24 m, which is 2 m below the proposed wet well floor. Little to no rock excavation is expected during the wet well construction.

8.4.3 Site Development and Clearing

The proposed Raw Water Pump Station site is a treed site adjacent to Comox Lake, accessed from Comox Logging Road. An area of approximately 0.6 hectares will be cleared of trees and brush to construct the pump station. The site area is 0.45 hectares, but additional clearing will be required to allow for fill placement.

There is an existing pullout on Comox Lake Road near the site, which conflicts with the proposed pump station site. The pullout will be moved to the east to provide sufficient space for the pump station. Concrete barriers will be required to protect the site from logging traffic travelling around the sharp curve in the road near the site.

The excavation for the wet well will extend approximately 15 m below grade. Due to the presence of groundwater below the level of Comox Lake, it is likely that shoring will be required to avoid collapse of the excavation. If the excavation is supported, allowing near vertical cuts, then the required excavation will be approximately 17,000 m^3. 13,000 m^3 of material will be displaced by the pump station wet well, which may be re-usable as general fill for site grading.

The site slopes towards Comox Lake. A maximum slope of 6% is required for operational purposes. Maintaining a 6% maximum slope facilitates pedestrian and vehicle movement, as well as loading and unloading equipment into the station for maintenance. Rough grading will be required to reduce the existing slopes to the required maximum.

8.4.4 Underground Site Services

Table 8-4 summarizes the underground services for the site.

Table 8-4: RWPS Underground Site Services

Service	Description
Stormwater	Stormwater will be managed by a system of overland flow and culverts as required. Stormwater retention will be provided at the RWPS site to attenuate flows to pre-development levels. Stormwater design requirements are discussed in detail in the Stormwater Management subsection.
Domestic Water	No domestic potable water service will be provided for the RWPS
Domestic Sanitary Service	No sewer service will be provided for the RWPS
Fish Hatchery Supply	Provision for either a 50 mm or 75 mm raw water supply with PRV will be included in the design within the pump station building.
Floor Drains	Drainage from the pump station floor drains will be directed to an infiltration manhole. The design infiltration capacity should be no less than 0.1 L/s of sustained flow. Overflow from the infiltration manhole will be to surface drainage.
Underground Electrical Duct Banks	set of conduits will extend from a power pole along Comox Lake Logging Road to a panel in the RWPS control room.

8.4.5 Vehicle Access, Roads, Parking

Parking and access to the raw water plant location is to accommodate a utility truck housing a 26 ton crane and a fire truck (equivalent TAC vehicle – HSU and I-Bus should be checked for turning movements). Table 8-5 summarizes design parameters of the access and loop roads to the raw water location.

Table 8-5: Raw Water Pump Station Road and Parking Area Design Parameters

Design Parameter	RWPS Site
Design Vehicle	Fire Truck and Utility truck with 26 tonne crane
Minimum Grade	1%
Maximum Grade	6%
Minimum Turning Radii at Intersection	To meet design vehicle turning movements
Parking spaces	1 service truck
Minimum parking stall widths	4.0 m
Pavement Structure	25-year service life H20 loading
Curb and gutter	Road will have gravel shoulders and drainage ditches where required.
Traffic signs	Manual of Uniform Traffic Control Devices for Canada, Latest Version
Pavement Markings	Manual of Uniform Traffic Control Devices for Canada, Latest Version

8.4.1 Stormwater Management

For the RWPS, three catchments were used for the existing site as described in Table 8-6 below.

Table 8-6: Catchment Area Characteristics

Sub-catchment	Area				Length (m)	Slope (m/m)
RWPS	m^2	km^2	Ha		Overland	
1	391	0.00039	0.039		47	0.053
2	642	0.00064	0.064		37	0.068
3	297	0.00030	0.030		28	0.125
Total or maximum:	**1,330**	**0.00013**	**0.133**		**47**	**0.125**

The main stormwater management objective for the RWPS is to control the turbidity of stormwater discharging into Comox Lake by adequate armouring of storm ditches. Storage of approximately 100 m^3 is required to control release to pre-development flowrates. Because space at the RWPS site is limited, use of below grade stormwater retention under paved areas can be considered.

The RWPS paved area will drain overland to the southeast, towards Comox Lake. The building roof drains can discharge overland to armoured ditches, dispersing to overland flow towards Comox Lake.

Stormwater retention measures may include:

- Pervious catch basins
- Infiltration trench
- Infiltration basin
- Reduced lot grading

8.4.2 Site Security

8.4.2.1 General

Overall site security is covered in detail in a separate section. This subsection describes security items which are related to civil works.

8.4.2.2 Fencing

Perimeter fencing around the RWPS to be galvanized steel 1.8 m tall chain-link with angled triple barbed wire surrounding developed portion of each site. Fencing to meet MMCD 32 31 13.

8.4.2.3 Gates

For RWPS, a gate is to be provided at the site entrance based on design vehicle requirements. Gates to meet MMCD 32 31 13, and to be equipped with rollers at base and triple barbed wire at top.

8.4.2.4 Site Lighting

Exterior lighting for the RWPS site will have the capacity to illuminate parking areas, pedestrian paths and building entrances.

Outdoor lighting will have both automatic and manual controls. Automatic controls will use motion-sensors and photocells to control the lighting. A manual switch inside the station will allow users to override automatic mode and turn exterior lighting on or off manually.

8.4.2.5 Bollards

Bollards will be fitted along the western perimeter fence line as indicated on the site plan, to prevent a vehicle from accidentally or maliciously breaching the perimeter fence line.

8.4.3 ESCP's

Erosion and Sediment Control Plans (ESCPs) are anticipated to be required for the following:

- Runoff during construction
- Disposal of water after hydrostatic and pressure testing
- Disposal of superchlorinated water following disinfection activities for treated water piping
- Flushing and cleaning
- Dewatering excavations

Sediment control can be achieved using a settling pond sized for the anticipated flows. Due to the riparian setbacks, the settling pond may need to be located above the site.

9. Land Conveyance Pipelines

Conveyance piping will consist of two transmission mains: a raw water transmission main and a treated water transmission main. The raw water transmission main will convey water from the RWPS on the northern shore of Comox Lake to the WTP in the vicinity of Bevan Road and Lake Trail Road. The treated water transmission main will convey water from the WTP's clearwell to the distribution system.

9.1 Geotechnical

[INSERT – SUMMARY FROM EXP GEOTECHNICAL REPORT APPENDIX B]

9.2 Codes and Standards

Table 9-1: Code and Standards

AWWA C200	AWWA Standard for Steel Water Pipe - 6 Inches and Larger
AWWA C203	Standard for Coal Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied.]
AWWA C210	Standard for Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
AWWA C222	Standard for Polyurethane Coatings Systems for the Interior and Exterior of Steel Water Pipelines
NSF 61	Drinking Water System Components - Health Effects

9.3 Alignment

9.3.1 Raw Water Alignment

The raw water alignment leaves the pump station site and traverses the TimberWest logging road to Colake Road. The departure from the logging road between stations 1+200 to 1+400 is to avoid a narrow and willow bedrock area and to minimize traffic impact.

9.3.2 Treated Water Alignment

The proposed treated water alignment leaves the WTP site and traverses to BC Hydro property and generally parallels the BC Hydro penstock within the BC Hydro property.

9.3.3 Indicative System Profile

The indicative pipe profile is shown in Figure 9-1.

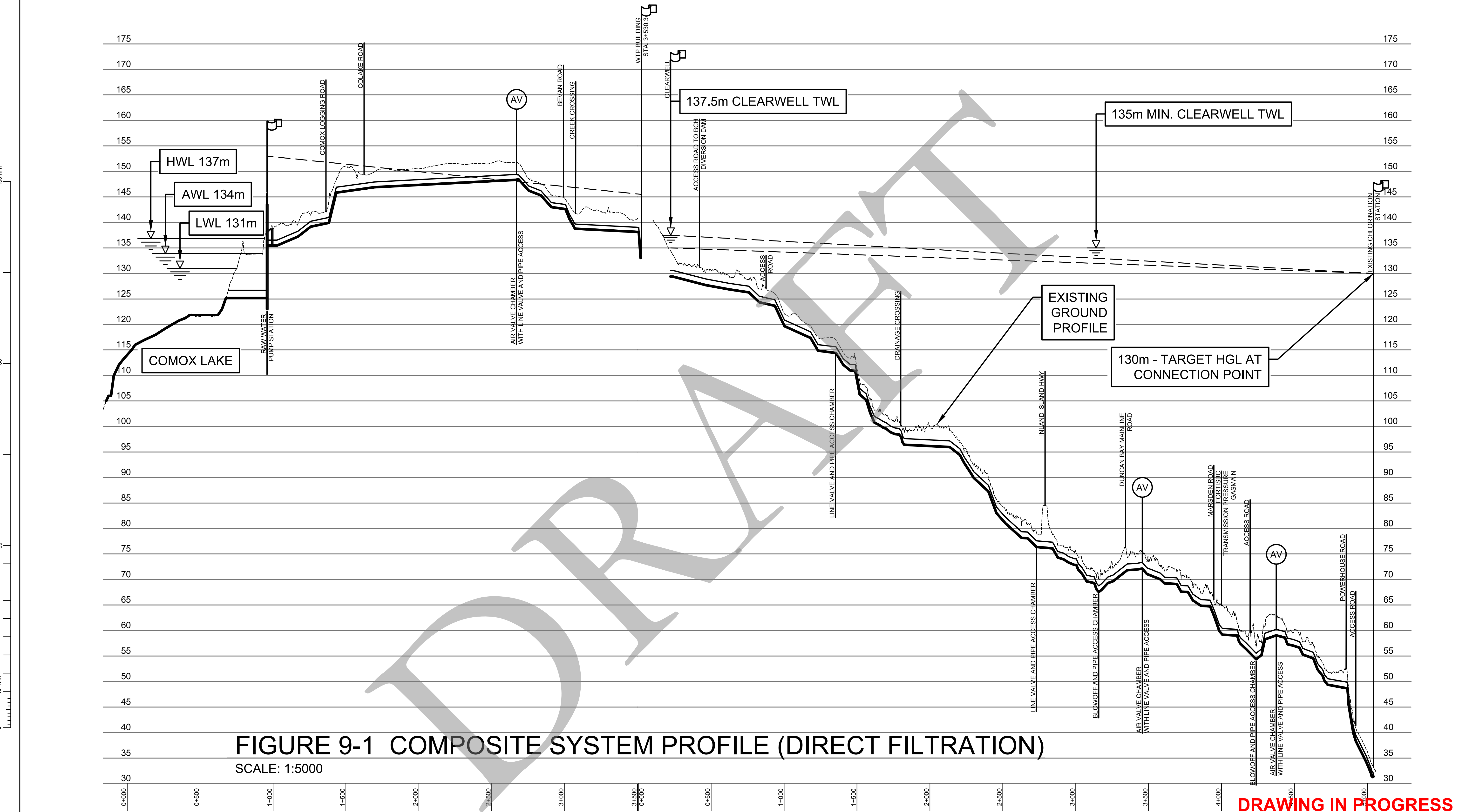

FIGURE 9-1 COMPOSITE SYSTEM PROFILE (DIRECT FILTRATION)

SCALE: 1:5000

DRAWING IN PROGRESS

PLOTTED ON 2017-09-18 AT 3:06 PM

1:1 @ A3 0 10 20 30 40 50 mm

COMOX LAKE
WATER TREATMENT PROJECT

OPUS
Kelowna Office
+1 250 868 4925
206 - 2365 Gordon Drive, Kelowna BC V1W 3C2, Canada

Designed	Approved	Approved Date
S. KRAS	T. PHELAN	
Drawn	Scales	
D. SAYERS	AS SHOWN	

Project: COMOX VALLEY REGIONAL DISTRICT
OWNER'S ENGINEERING SERVICES
COMOX LAKE WATER TREATMENT PROJECT

Sheet: FIGURES
D-13124.00_FIGURE-9-1 - FIGURE 9-1

Project No.	Sheet No.	Revision
D-13124.00	FIG 9-1	1

9.4 Depth of Bury

The minimum cover for the raw water and treated water transmission mains is 1.2 m above the crown of pipe. If it is not practical to provide 1.2 m cover, then rigid polystyrene insulation should be placed directly above the pipe crown to provide equivalent thermal resistance to 1.2 m of soil cover. For travelled areas with less than 1.2 m cover, a concrete slab should be constructed over the pipe designed to distribute traffic loading to compensate for the shallow cover.

9.5 Common Corridor Utilities

Fiber Optic commutation between the WTP and the RWPS will be installed at the same time and in the same location as the raw water transmission main.

9.6 Pipeline Appurtenances

The following appurtenances will be included in the conveyance pipeline where their locations are dictated by the topography and elevation profile.

a. Line Valves
b. Air Release Valves
c. Blowoffs

9.7 Crossings

9.7.1 Creek Crossings

The raw water transmission main will cross Bevan Creek near the intersection of Bevan and Lake Trail Roads. The treated water transmission main (Penstock Alignment) will cross Bevan Creek northeast of Highway 19. Bentonite dams perpendicular to the pipe will be required in any area of high groundwater to prevent migration of groundwater or surface water through the pipe bedding.

A construction environmental management plan will be required for each crossing to define fish salvage, construction windows, erosion and sediment control, and reinstating of the creek channel and bank conditions.

9.7.2 Fortis Gas Main Crossing

The treated water main crosses a high-pressure gas main near Marston Road. The water main will be located under the gas main. The gas main is 275 mm diameter at a depth of approximately 4 metres. Physical location of the gas main will be required by DB team using hydrovac or other excavation to confirm horizontal and vertical location.

9.7.3 Highway Crossings

The treated water transmission main will cross Highway 19, which is managed by the BC Ministry of Transportation and Infrastructure (MOTI). Any crossing of Highway 19 must be constructed by pipe-jacking.

9.8 Tie-Ins

The treated watermain will tie into the existing distribution system immediately upstream of the existing chlorination facility near the BC Hydro Puntledge River Substation. Although the existing chlorination system is to be decommissioned, the watermains through the facility will remain in place. Access to existing flowmeters valves and ports in the facility will be maintained. The watermains are to be buried with a minimum of 1.2 m of cover following demolition of the structure, or housed within insulated concrete chambers where applicable.

The existing chlorination system may remain in service during the construction period to facilitate phasing of work. System flows are to be maintained without interruption.

9.9 Design Pressure

The pipe and fittings will be designed to the maximum hydraulic grade line (HGL) of the system. The design pressure is calculated as shown in Table 9.2. The treated water pipeline can also be rated by station so that lighter wall pipe can be used at lower pressure stations.

Table 9-2: Conveyance Pipelines Design Criteria

CRITERIA	RAW WATER TRANSMISSION MAIN	TREATED WATER TRANSMISSION MAIN
Static Delivery HGL, metres	149	139
Maximum Dynamic Delivery HGL, metres	156	139
Minimum Pipeline Elevation, metres	135	35
Maximum Pipeline Pressure, metres	21	104
Maximum Operation Pressure, kPa (psi)	210 (30)	1020 (148)
Surge Allowance, kPa (psi)	345 (50)	345 (50)
Design Pressure, kPa (psi)	555 (80)	1365 (198)

9.10 Pipe Material

The water conveyance pipe material will be welded steel designed and installed in accordance with the following:

a. AWWA M11 (Current Edition) Manual of Water Supply Practices – Steel Water Pipe: A Guide for Design and Installation
b. Applicable AWWA Standards (e.g. AWWA C210-15, AWWA C200, etc.)
c. MMCD Platinum Edition for civil works (backfill material gradations).

The pipe and fittings will be designed to the pressure ratings in Table 9.1. Trench dams will be required on any portion of the water transmission main with a grade greater than 8%.

9.11 Sizing and Pressure Ratings

The sizing and pressure ratings will be designed by the Proponent in accordance with ASTM, AWWA and other design best practice guidelines and specifications. The transmission mains will be between 610mm –1218mm (24" – 48").

9.12 Lining, Coating, and Corrosion Protection

9.12.1 Exterior Coating

The exterior surface coating (application, testing and repair), unless specified otherwise, will be Polyurethane to AWWA C222 [or Coal-tar enamel coating to AWWA C203].

9.12.2 Interior Lining

The interior surface lining (application, testing and repair), for all watermains, will be 100% solids liquid epoxy to AWWA C210. Only products with three years proven municipal water pipeline experience will be considered.

9.12.3 Cathodic Protection for Steel Pipe and Fittings

Cathodic protection will be provided if the surrounding conditions require it.

9.13 Seismic

All design works associated with the pipe conveyance will conform to seismic design requirements set out by the governing body and good industry practice.

All designs and equipment shall have a certificate of Unit Responsibly signed by a Professional Engineer stating that computation has been carried out and the all components and designs have been sized to perform in certain seismic conditions as indicated.

Additional criteria will be added following geotechnical investigations which will be completed by EXP.

9.14 Pipe-Jacking Requirements

The casing pipe diameter will be sufficient to house the carrier pipe(s) and any other utilities the owner wants it to carry. The casing pipe wall thickness will be sufficient to withstand the jacking/ramming forces during installation and the loading from the highway, post installation. This will be dependent on the depth of cover.

Existing utilities will need to be exposed and locations confirmed prior to starting work. Proposed entry and exit pit locations, dimensions and shoring will be submitted for review.

Pipe joints within the casing pipe will be restrained. Casing spacers will be used to prevent the carrier pipe bell from touching the casing and to maintain a uniform space between the carrier pipe and casing interior. Casing spacers will be installed on the carrier pipe at intervals per the manufacturer's recommendations with a minimum of three spacers per pipe section equally spaced. Either end of the casing pipe will have a double set of spacers and will be sealed with a suitable rubber or heat shrink sleeve.

9.15 Pipeline Testing and Cleaning

All pipeline testing and cleaning will be carried out in accordance with AWWA C200 and best practice procedures.

All pipelines will be hydrostatically tested and:

- 10% of all butt welds will be tested by radiography,
- and 100% of all welds will be visually tested.
- All drinking water pipes will be disinfected and flushed: AWWA C651

10. Structural

10.1 Overview

This section identifies the codes and standards applicable to structural design criteria, and summarizes the loading criteria, materials and structural system requirements, and structural design approaches for each of the structures to be constructed for the project.

10.2 Applicable Codes and Standards

The strength, serviceability, and quality for materials and design procedures will meet the requirements of the following Canadian (and in case of deficiency in Canadian codes and standards, American) codes and standards:

- 2012 British Columbia Building Code, BCBC 2012
- 2015 National Building Code of Canada, National Research Council Canada
- American Society of Civil Engineers (ASCE)/SEI 7-10, Minimum Design Loads and Associated Criteria for Buildings and Other Structures
- CSA-A23.3-14 - Design of Concrete Structures
- CSA A23.1-14/A23.2-14 - Concrete materials and methods of concrete construction/Test methods and standard practices for concrete
- American Concrete Institute (ACI) 318M-14, Building Code Requirements for Structural Concrete
- ACI 350-06, Code Requirements for Environmental Engineering Concrete Structures
- ACI 350.3-06, Seismic Design of Liquid-Containing Concrete Structures
- CAN/CSA-S304.1, Design of Masonry structures
- Seismic Design Guide for Masonry Buildings, Canadian Concrete Masonry Producers Association, April 2009
- TMS 402/602, Building Code Requirements and Specification for Masonry Structures
- CSA-S16-14 Design of Steel Structures
- American Institute of Steel Construction (AISC), Steel Construction Manual, 15th Edition including AISC 360-16, Specification for Structural Steel Buildings
- AISC 341-16, Seismic Provisions for Structural Steel Buildings
- CSA W59-13 - Welded steel construction (metal arc welding)
- American Welding Society (AWS) D1.1/D1.1M, Structural Welding Code- Steel – 23rd Edition
- Canadian Sheet Steel Building Institute (CSSBI), Design of Steel Deck Diaphragms - 3rd Edition
- Manual of Construction with Steel Deck – No. MOC3, Steel Deck Institute (SDI) SDI, Diaphragm Design Manual, 4th Edition
- Canadian Sheet Steel Building Institute (CSSBI), Lightweight Steel Framing Design Manual - 2nd Edition 2006
- CSA S136-16 North American specification for the Design of Cold-Formed Steel Structural Members
- American Iron and Steel Institute (AISI) S100-2012, North American Specification for Design of Cold-Formed Steel Structural Members
- American Association of State Highway and Transportation Officials
- CAN/CSA-S157-05/S157.1-05 (R2015) - Strength Design in Aluminum
- AA ADM, Aluminum Design Manual (2015)
- AWS D1.2/D1.2M, Structural Welding Code-Aluminum – 6th Edition
- CSA W59.2-M1991 (R2008) - Welded Aluminum Construction
- ICC-Evaluation Service (ICC-ES) – Evaluation Reports for specific products
- WorkSafeBC
- National Fire Code of Canada 2015, National Research Council Canada
- Town of Comox Bylaw 1472, Building Bylaw (January 2015)

10.3 Loading Criteria

10.3.1 Dead Loads

Dead loads will include the weight of all materials required to construct the structure, such as walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding, and other similar structural and architectural items. Fixed service equipment, including tanks, pumps, fixed equipment, partitions, equipment pads and similar items, will be added to the total dead load.

10.3.2 Superimposed Dead Loads

An approximate allowance of 0.50 kPa to 0.75k Pa will be provided for suspended utilities, including small-diameter mechanical piping, lights, ducts, conduit, and cable trays. An additional approximate allowance of 25 kPa will be provided for fire sprinkler systems, where applicable.

10.3.3 Live Loads

Design Live loads will be:

a. As per BCBC 2012, 4.1.5. Design Loads Due to Use and Occupancy.
b. As per specific requirements of the plant
c. Areas subjected to vehicle loadings shall be designed for AASHTO H20 Loadings

10.3.4 Seismic Loads

Design Seismic loads will be:

a. As per BCBC 2012, 4.1.8. Earthquake Load and Effects.
b. As per Geotechnical Report providing seismic criteria, based on ground specifications at specific site locations. (RWPS, Pipe Alignment)
c. Based on the type of Seismic Resisting Structural System (SFRS)
d. Hydrodynamic loads to comply with Chapter 15 of ASCE 7, ACI 350 and ACI 350.3-06 provisions

Table 10-1: Seismic Data (Town of Comox Bylaw 1472 and BC Building Code, 2012)

Parameters	$S_a(0.2)$	$S_a(0.5)$	$S_a(1.0)$	$S_a(2.0)$	***PGA***
Comox	0.66	0.49	0.29	0.16	0.30

10.3.5 Wind Loads

Design Wind loads will be:

a. As per BCBC 2012, 4.1.7. Wind Load & Division B Appendix C
b. As per City of Comox Permits Bulletin No. 07-003

Table 10-2: Wind Data (Town of Comox Bylaw 1472 and BC Building Code, 2012)

Location	**Hourly Wind Pressures, kPa**	
	1/10	**1/50**
Comox	0.40	0.52

10.3.6 Snow & Rain Loads

Design Snow and Rain loads will be:

a. As per BCBC 2012, 4.1.6. Loads Due to Snow and Rain & Division B Appendix C
b. As per City of Comox Permits Bulletin No. 07-003

If needed, additional requirements included in the User's Guide – NBC 2012 Structural Commentaries (Part 4 of Division B) will be considered.

Table 10-3: Temperature Data (Town of Comox Bylaw 1472 and BC Building Code, 2012)

Location	Elev., m	Design Temp January		Design Temp July 2.5%		Degree Days Below 18°C
Comox	15	-7	-9	27	18	2978.7

Table 10-4: Rain Data (Town of Comox Bylaw 1472 and BC Building Code, 2012)

Location	One Day Rain, 1/50, mm	Ann. Rain, mm	Moist. Index	Ann. Tot. Ppn., mm	Driving Rain Wind Pressure, Pa, 1/5
Comox	10	106	1175	1.28	1200

Table 10-5: Snow Data (Town of Comox Bylaw 1472 and BC Building Code, 2012)

Location	Snow Load, kPa, 1/50	
	S_s	S_r
Comox	2.6	0.4

10.3.7 Earth Loads

Earth loads will adhere to the recommendations given in the final geotechnical report which will provide soil characteristics and imposing loads.

10.3.8 Geotechnical Design Parameters

The following criteria are taken from the Final Interpretive Geotechnical Report;

a. Type of suitable foundation and Soil Bearing Capacity for buildings, structures and pipelines (both dry and submerged conditions)
b. Site Class B (Fa = 0.9, Fv = 0.7)
c. Total and differential settlement
d. Unit weight and other specifications of soil and backfilling
e. Lateral soil pressure for static and dynamic (seismic) conditions
f. Establish groundwater elevation for project site
g. Recommended methods of shoring, excavation and dewatering during construction
h. Identify potential geological hazards that may exist at the site and recommend mitigation measures

10.4 Materials/Structural System Requirements

10.4.1 Structural Materials and Strength

The following represents the typical materials and strengths that will be used. Specific areas may be revised to meet the design criteria that could not be determined at this stage.

Table 10-6: Concrete Criteria

Location	Min Compressive Strength	Class
Slab-on-Grade	25 MPa	C2
Loading Dock and Exterior Slabs	35 MPa within 56 days	C1
Interior Slabs-on-Deck	25 MPa at 28 days	N
Foundation Walls, Grade Beams, Footings	35 MPa	F2
Skim Coats	10 MPa at 28 days	

Location	Min Compressive Strength	Class
Exterior Un-reinforced Concrete (Sidewalks, Curbs, etc.)	32 MPa at 28 days	C2
Walls	35 MPa	F2 (below grade)

Masonry

- Min. Compressive Strength: 14 MPa

Reinforcing Steel

- Grade: 400 MPa
- Sizes: 10M to 45M

Structural Steel:

- New carbon steel conforming to G40 Series Structural Quality Steel
- Rolled Shapes: 350 MPa
- Hollow Structural Sections: 350 MPa
- Angles and Plates: 300 MPa
- 38 mm – 76 mm Metal Decking: 230 MPa
- All exterior exposed steel shall be Hot-Dip Galvanized Steel.

10.4.2 Concrete Design

a. CAN/CSA-A23.3-14 - Design of Concrete Structures
b. American Concrete Institute (ACI) 318-14, Building Code Requirements for Structural Concrete
c. ACI 350-06, Code Requirements for Environmental Engineering Concrete Structures
d. ACI 350.3-06, Seismic Design of Liquid-Containing Concrete Structures

10.4.3 Masonry Design

a. CAN/CSA-S304.1, Design of masonry structures
b. Seismic Design Guide for Masonry Buildings, Canadian Concrete Masonry Producers Association, April 2009

10.4.4 Structural Steel

a. CAN/CSA-S16-14 Design of Steel Structures
b. American Institute of Steel Construction (AISC), Steel Construction Manual, 15th Edition including AISC 360-16, Specification for Structural Steel Buildings
c. AISC 341-16, Seismic Provisions for Structural Steel Buildings including Supplement No. 1
d. CSA W59-13 - Welded steel construction (metal arc welding)
e. American Welding Society (AWS) D1.1/D1.1, Structural Welding Code- Steel – 23rd Edition
f. American Iron and Steel Institute (AISI) S100-2012, North American Specification for Design of Cold-Formed Steel Structural Members

10.4.5 Metal Decking

a. Canadian Sheet Steel Building Institute (CSSBI), Design of *Steel Deck* Diaphragms - 3rd Edition
b. Manual of Construction with Steel Deck – No. MOC3, Steel Deck Institute (SDI) SDI, Diaphragm Design Manual, 4th Edition
c. Canadian Sheet Steel Building Institute (CSSBI), Lightweight Steel Framing Design Manual - 2nd

Edition 2006

d. CSA – S136-16 North American specification for the Design of Cold Formed Steel Structural Members

10.4.6 Aluminum

a. CAN/CSA-S157-05/S157.1-05 (R2015) - Strength Design in Aluminum
b. AA AD, Aluminum Design Manual (2015)
c. AWS D1.2/D1.2M, Structural Welding Code-Aluminum – 6th Edition
d. CSA W59.2-M1991 (R2008) - *Welded Aluminum* Construction

10.4.7 Fiberglass

Liquid hypochlorite tanks and operating floor will be constructed from fiberglass, otherwise fiberglass will only be used in highly corrosive locations where other materials are not suitable. The structural usage is anticipated to be limited to grating, platforms, and railings. Design procedures will include review of corrosion resistance requirements of resin with the lead process engineer(s) and the project corrosion engineer before selection and use. Unless otherwise recommended, all fiberglass-reinforced plastic products will be manufactured by a pultruded process using vinyl ester resin and will meet self-extinguishing fire retardant requirements of ASTM D635. Exterior fiberglass-reinforced plastic products will have an additional 1.5-mil-thick UV coating, helping to shield the product from UV light. All cut ends and holes will be sealed with resin to prevent intrusion of water.

10.5 Structural Design Criteria

10.5.1 Performance Design Considerations

Post disaster performance of a building is defined by the structures ability to maintain its function and safety during and after extreme environmental events. The WTP and RWPS structures will be designed as post-disaster structures (BC Building Code).

10.5.2 Serviceability Requirements

Serviceability requirements will be checked against the requirements specified in the British Columbia Building Code and all other applicable reference standards including CSA S16.1-14 Design of Steel Structures.

Piping system connections at structures and tanks shall have adequate flexibility to allow for the minimum movements as shown on ASCE 7; table 15.7-1.

11. Architectural

11.1 General

11.1.1 Facility Programming

The proposed Water Treatment Facility is a combined plant and administration offices facility. The building will also provide administrative office space for the Waterworks Department combined with the administrative office of the water treatment plant as illustrated in Figure 11-1 and 11-2.

Figure 11-1 WTP Facility ISO View

Figure 11-2 WTP Exterior View

The program areas are as follows:

[INSERT – PROGRAM TABLE HERE WHEN SUPPLIED]

11.2 Design approach by facility

11.2.1 WTP

See below.

11.2.2 RWPS

The Raw Water Pump Station, due to its remote location and adjacency to a gun range will need to be literally bullet proof. The design intention is to construct a rugged durable vandal proof building to house the raw water pumps that blends as much as possible into its lakeside forest edge context.

Rough faced concrete block is proposed as the main façade material. Galvanized steel will be used for the stairs. The upper Electrical Room is to be clad in vertical heavy duty steel channel siding in a dark charcoal to minimize its presence.

11.3 Code Review and Building Designation

11.3.1 Building Codes

The architectural design criteria will meet the requirements of the following codes and standards:

- 2012 British Columbia Building Code
- 2012 British Columbia Fire Code
- Americans with Disabilities Act and International Code Council/American National Standards Institute A117.1
- BCBC 2012 - 3.2.2.83 Group F Division 3
- BC Building Access Requirements & Guidelines

11.3.2 Designation

11.3.2.1 POST DISASTER:

The buildings must be built to post-disaster standards of the Building Code. All buildings must meet the 2012 BCBC requirements.

11.3.2.2 OCCUPANCY:

The Occupancy Classification for the WTP is Group F, Division 3, Low-Hazard Industrial Occupancy.

At 4,010 m^2 in area, the building is further classified as Group F, Division 3, up to 6 Storeys with the following requirements:

- Building area not to exceed 4,800 m2
- Non-combustible Construction
- Fire Resistance ratings - not less than 1 hour for Floor and roof assemblies and load bearing walls and elements.
- Roof Assemblies not less than 1 hour

11.3.3 Chemical Storage Requirements

Section 3.3.6 of the 2012 BCBC governs the storage of dangerous goods within buildings where the volume exceeds pre-defined limits based on the type of chemical. Details of the storage requires are referenced to the 2012 BC Fire Code, which becomes the governing document.

The BC Fire Code applies the chemical designations provided in the Transport Canada (TC): Consolidated Transportation of Dangerous Goods Regulation (SOR/2014-152), which define a chemical by a Class 1-9, package I-III. Chemical classification is typically provided on the suppliers MSDS sheet. Sodium hypochlorite at concentrations greater than 7% is classified as a Class 8, package III chemical according to the available MSDS sheets. As per TC regulations this is defined as a low risk corrosive chemical. It is worth noting that 12% sodium hypochlorite is not considered an oxidizer under the TC regulations, but is under the UN designation. The storage of less than 2000 kg or 2000 L of a Class 8III chemical is exempted from the BC Fire Code per Table 3.2.7.1 – Small Quantity Exemptions for Dangerous Goods. As the quantities of chemical is above 2000 L Section 3.2.7 – Indoor Storage of Dangerous Goods applies to the building or part thereof.

The fire code requires the dangerous goods to be stored in a fire compartment which is defined as a portion of the building which has a fire rating. Furthermore, the following are required:

- Open flames or spark producing devices shall not be used (3.2.7.2.3),
- Rooms shall be dry and cool and provided with a ventilation system (3.2.7.3),
- Areas shall be free of waste and debris (3.2.7.4)
- Maximum tank heights shall be less than 6 m for chemical tanks in areas provided with a fire protection system (Table 3.2.7.5)
- The fire suppression system shall comply with the BC Fire Code (3.2.7.5.3)

11.4 Architectural

The CVRD intention for the WTP facility to use it as a showcase building suitable as public presentation space for water treatment and stewardship available for local public tours such as education for schools and community. Refer to Figure 11-3 which illiterates the WTP entrance.

Figure 11-3 WTP Entrance

11.4.1 Design Response:

The design intent for the facility is to have the public portion of the building be open and welcoming, inviting visitors to visually engage the facility, with the remainder of the building being a well detailed relatively mute background setting off the public “pavilion” expression. The facility design is intended to be harmonious with its forest context. The language of the building will connect the Comox Valley’s history of wood industry with contemporary expression.

The public portion of the building will be largely glazed, with large roof overhang with wood soffit. The plant portion of the building will be clad in vertically charcoal metal channel siding, on a base of exposed concrete on the lower floor. As the upper floor of the plant is lit by skylights, few openings will be required in the exterior walls. The roof of the entire facility will be flat SBS membrane roofing.

An expressive wood post and beam frame structure welcomes visitors into the Public Lobby – a space of orientation to the workings of the water treatment processes. The public entry is tall light filled glass volume projecting out past the main building volume. A portion of the North wall of the public entrance shall be wood siding to block views into the truck unloading area.

The lobby will showcase the use of locally sourced wood in structural columns and beams, soffit, bench and wall paneling to create a warm and welcoming environment as well as to demonstrate its environmental and economic sustainability in the community. The lobby projects to the west out over the parking area further distinguishing its public qualities from the rest of the building. This glazed large bay window will view to the forest beyond, connecting the visitor with the natural environment.

Materials are to be selected on the basis of their durability and ease of maintenance:

- Glazing for Public Portion of the building to be double glazed in anodized thermally broken aluminum curtain wall frames.
- Wood (Cedar) to be used where well protected by overhang or in soffit condition to minimize maintenance.
- Steel cladding and flashings to have long lasting finish and be of substantial gauge to withstand its industrial use.
- Exposed concrete walls to be cast-in-place with careful joint pattern.

11.4.2 Indigenous Cultural Content

The building is an opportunity create dialogue with and give voice to First Nations and their traditional territories integration with wildlife, especially the fisheries activities within the Puntledge River and the Comox Lake. An example is illustrated in Figure 11-4.

All options for incorporating indigenous content into the facility should be undertaken in consultation with the K'omoks First Nation and employing/commissioning local First Nations artists. This needs to begin at the start of the project – not be an add on later. All works should serve to reflect local culture and the importance of caring for nature and clean water.

Figure 11-4 WTP Indigenous Art

Some preliminary options have been identified for the facility:

a. Public Art:

   i. *Commission an art work to sit in the entry plaza. This should be in a material that will stand the test of time.*

b. Integration with Building:

   i. *The glazing could be treated with a K'omoks motif – in fritted glass or vinyl. See rendering.*
   ii. *Integrate K'omoks art into a rain water treatment – highlighting need to care for water.*

11.4.3 Building Siting

The buildings will be sited to take maximum advantage of the orientation to sunlight and prevailing winds, and to have a minimal impact on the site's natural characteristics. The siting of the buildings also takes advantage of the terrain to minimize excavation and improve operator friendliness.

The front entry is located facing the road and main entry to the site. Parking for both staff and visitors is located on the south west side of the building with staff entry to both offices and mudroom below located adjacent. Beyond the parking, the site is accessed via security gates. A key strategy to provide security while minimizing the appearances of a heavily cordoned facility, is to use the building as a part of the fence. Refer to the Site Plan for the fence and access and egress gates.

A public info and amenity node is located to the south of the entry where it leaves the road. This feature will contain information boards explaining the processes of the water treatment plant, environmental education about the bio-region, as well as maps of the local trail system. It could be supported by a water bottle fill station and fountain. See Figure XX

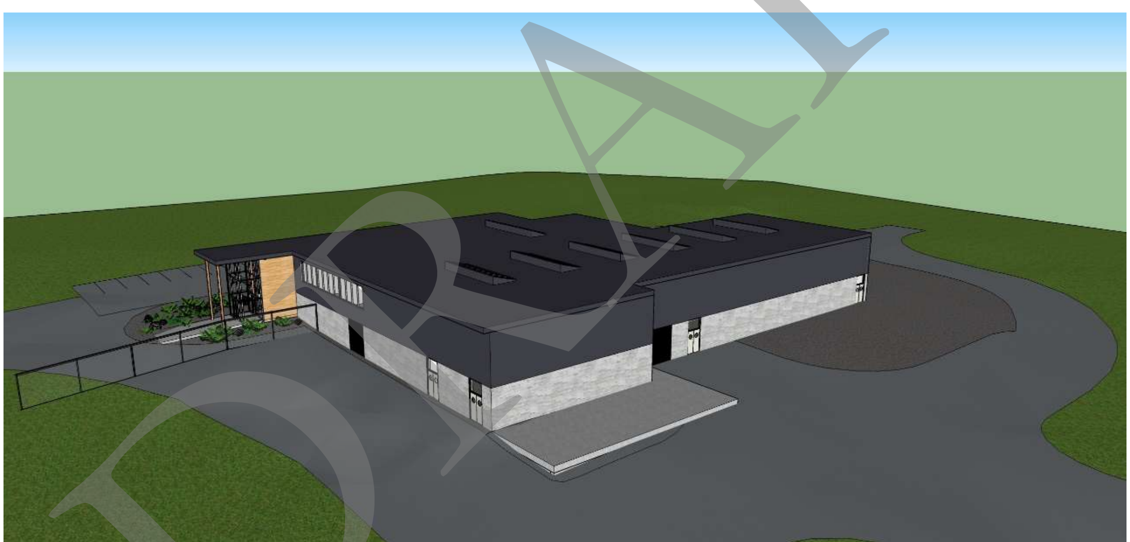

Figure 11-5 WTP Facility Site Overview

11.4.4 Parking Requirements:

30 combined visitor and staff parking spaces in asphalt parking lot – two of these will be accessible.

11.4.5 Landscaping

a. The intent is to return the surrounding exterior areas not used for parking, roadways, etc to its natural state in a natural low maintenance landscape. Areas disturbed by construction should be reconstructed with natural habitat.
b. Retain existing trees, shrubs and grasses where possible.
c. All new planting to be indigenous species that thrive in this location such as ferns, cedar, fir.
d. An Entry Plaza will be a combination of planted and hardscape.
e. Where security fences face the public areas, effort will be made to provide landscape screening.

11.4.6 Heating, Ventilating and Cooling

Refer to Section 13.2.

11.4.7 Lighting Systems

The buildings' total lighting energy will be reduced using:

- Natural lighting to reduce the reliance on artificial lighting. All offices have access to natural light and the plant area is lit via a series of skylights over the walkways.
- Direct/indirect LED lighting to produce higher quality standards.
- Individual control systems or motion sensory controls for the lighting system.
- Site lighting will be minimized and focused downwards to reduce light pollution and protect the night sky.
- Installation of lighting systems will consider requirements for bulb replacement so that the use of ladders will be minimized where practical.

12. Process-Mechanical

12.1 Overview

This section presents general information related to the process-mechanical design criteria, including references and guidelines to be used in the process design and the type and material for piping and valves.

12.2 Open Channel Hydraulic Design

Process hydraulic structures and free water surface, open channel conduits will be used for the main process flow and will be cast-in-place formed concrete. Maximum channel velocities will not exceed 1.4m/sec under any hydraulic condition and entrance/exit velocities will not exceed 0.75 m/sec. Channel shape transitions or directional changes will use concrete fill or flow vanes for a turn radius to improve flow lines. Where localized, non-uniform velocities may exist such as at exit, entrance, or changes in flow direction, considerations shall be made for flow vanes.

All open surface hydraulic structures below maximum static hydraulic grade shall incorporate overflow. The overflow shall be sized for the maximum hydraulic flow rate plus a minimum safety allowance of 20 percent. Channel hydraulic calculations shall be based on Manning's equation using a roughness coefficient no less than n=0.012.

12.3 Pipe Design

12.3.1 Pipe Sizing

Pipe sizes will be selected based on velocity and headloss calculations. Maximum pipe velocity will be 2.0 m/sec unless otherwise required at flow meters and control valves for proper operation. Where new piping connects to existing piping, pipe sizing will be matched. For special conditions, maximum velocities up to3.7 m/sec may be allowed. Pipe sizing for process commodities which have settleable solids will maintain a minimum scour velocity.

Pump suction piping will be sized for a maximum of 1.5 m/sec, and pump discharge piping will be sized for a maximum of 1.8 m/sec.

12.3.2 General Requirements

Piping systems will be identified by the material code indicated on the P&IDs as line markings adjacent to the line, indicating the pipe size, process code, material code, and pipe sequence number.

In-plant piping will be located using good engineering practice, allowing for access and maintenance to all piping service points, including space for valve actuators and piping disassembly. All in-plant piping will be fully restrained joint without exception. The following minimum guidelines will be incorporated for all piping systems:

- Mechanical joints or couplings will be provided at all valves and equipment.
- Air release, venting, and vacuum relief (as required) will be provided at all high points in liquid piping.
- All piping will have drains at low points.
- All off-gassing liquid piping will have pressure relief valves between any isolation points or valves.
- Restrained mechanical joints will be flanged, harnessed coupling, restrained dismantling joints, grooved coupling, or threaded according to pipe size and material.
- An appropriate extra allowance of service connections shall be provided for future use and for use during start-up and commissioning.
- Sample taps to main process flows shall be at the centerline of the pipe and shall extend from the wall.

Piping layout, supports, and elevated structures for piping support purposes will be designed to provide the minimum horizontal clearances, and vertical clearances between finished grade (or top of floor) and the bottom of the piping system, shown in Table 12-1.

Table 12-1: Required Clearances

Location	Minimum Required Clearance
Above door entrances into building	300 mm
Above pedestrian walkways	2,500 mm
Above stairways, walkways, and elevated platforms	2,500 mm
Aisles between equipment and piping	900 mm
Exit routes beside equipment	1,000 mm

Piping for Pump Systems - Piping systems for centrifugal pumps will meet the requirements of the Hydraulic Institute (HI) Standards. Suction lines for horizontal centrifugal pumps will have a minimum of five (5) pump suction nozzle size diameters of straight run of pipe between the weld on the long radius elbow and the face of the pump nozzle flange. No tees, crosses, valves, or permanent installed strainers will be in the straight run. Line isolation valves will be provided for all pumps. If a reducer is required on the pump suction piping, eccentric reducers will be used and installed flat on top. Pressure indicators will be installed in the discharge piping upstream of the check valves.

Pipe wall thickness will be the maximum value determined from the following specified criteria:

- Internal pressure including surge
- External pressure/vacuum
- Handling
- External loads/deflection

12.3.3 Pipe Materials

Pipe material will be selected for the process commodity accounting for pipe material strength, resistance to corrosion, operating temperatures, lining and coating compatibility, overall durability, and economics. The Project process commodities and default piping material selections are shown in Table 12-2

Table 12-2: Process Piping Materials

Commodity	Size (mm)	Pipe Material/System
Process/Service Water	50 – 150	Schedule 80 CPVC or 316L SS
Sodium Hypochlorite Solution (10% - 15%)	12-50	Polyvinylidene (PVDF) or Hylar Schedule 80 CPVC
Chemical Services (coagulant, caustic soda, soda ash solution, polymer)	25-75	Schedule 80 PVC
Chlorine Solution – Below grade	50 – 200	High Density Polyethylene
Raw Water, Filtered Water, Spent filter backwash water, Maturation Water, Overflow for water, Treated Water	250 to 1200	Lined and coated steel pipe
Process Air	100 to 200	316L SS
Process Drains	50 – 200	Schedule 80 PVC
Compressed air	0.5 – 25	Extruded Aluminum or Type K Copper

12.3.4 Steel Pipe Design

Carbon steel pipe design will be performed in accordance with AWWA M11 and C200. The steel pipe will have fabricated steel fittings conforming to AWWA C208. Flange fittings will be used for attaching pipe to pumps, valves, or other appurtenances, according to AWWA C207 flange pressure rating for steel pipe. Carbon steel pipe will be lined based on AWWA C210 – Epoxy Lining, and coated based on AWWA C220 – Polyurethane Coating.

Stainless steel piping will be Type 316L designed to AWWA C220.

Minimal buried piping is expected for the Project. Design of the pipe for external loading will consider the depth of earth cover, live loads, and construction loads. If the pipe is below the groundwater table, buckling and flotation of pipe will be reviewed.

12.3.5 Linings, Coatings and Cathodic Protection

Buried yard piping will evaluate and implement as required either induced current cathodic protection (ICCP) or passive cathodic protection (PCP). Therefore, insulating joints will be used to cathodically protect the steel pipes from: (a) the ICCP/PCP systems, (b) other pipes of dissimilar metal, and (c) at the entrance to structures.

Corrosion protection for buried carbon steel piping cathodically protected can be accomplished using appropriate dielectric coating technologies such as tape coating. (Cement mortar is not considered a dielectric coating, and it is usually not used where soil electrical resistivity is below 1000 ohms-cm.) For additional corrosion protection, bonded joints and test monitoring stations are used.

Insulated flanges with test stations will be used for buried dissimilar piping connections and at concrete wall penetrations. Concrete wall penetrations shall insulate exterior buried piping from the building's reinforcing steel and building grounding system.

12.4 Valves and Actuators

12.4.1 General Design Requirements

Main process line operating and isolation valves will be shown on the process and instrumentation diagrams (P&IDs). Valve selection will be suitable for the application with regard to compatible materials, headloss, flow control, and cost.

The locations of valves and valve actuators (actuators, hand wheels, handles and stems) will not obstruct operating aisles, walkways, or platforms. Isolation valves will be located at grade level or will be provided with unobstructed and safe access. To the extent possible all isolation valves will be readily accessible from grade or from permanent platforms. Where existing valves are being replaced, alternate locations may be considered or located to match current arrangement and accessibility.

12.4.2 Butterfly Valves

Selection of the pressure class rating of the valves will be based on the maximum combined pressure considering pump shutoff head, maximum hydraulic grade line (HGL), static head, and surge pressure. AWWA C504 butterfly valves will be provided for isolation at pump suctions and discharges and to isolate processes to size 150mm.

12.4.3 Gate Valves

Gate valves will meet the requirements of American National Standards Institute (ANSI) Class 150 or 300 when required to meet system pressure requirements. Resilient-seated gate valves for drainage piping will be in accordance with AWWA C515-15. All valves that have direct buried installations will be manually actuated via buried valve actuators equipped with a standard AWWA 2-inch wrench nut.

12.4.4 Check Valves

Check valves will be provided on the discharge of pumps and will be sized to meet the capacity of the pump. Check valves will be selected to minimize “water-hammer” effects. Check valves will be of the self-closing type (spring assisted) and will not depend on flow reversal to effect closure.

12.4.5 Chemical Isolation Valves

Ball valves for sodium hypochlorite service will be Chemline Type 21. Ball valves will be true union type with Viton seals for hypochlorite service and other as selected for chemical compatibility with the related process. The ball will be vented for sodium hypochlorite service.

12.4.6 Diaphragm Valves

Diaphragm valves for sodium hypochlorite service will be considered for secondary isolation location (low open/close cycles).

12.4.7 De-gassing Valves

De-gassing valves will be used on hypochlorite piping at high-point and in-between all pairs of isolation valves. They will vent to a dedicated vent pipe system.

12.4.8 Chemical Service Actuators

Ball and butterfly valves will be supplied with manual actuators unless automation is required for the operation of the chemical feed system. If automated actuators are required they will be electric with a manual override. The manual override will be a handwheel that does not require declutching such as Rotork ROMpak series valves.

12.4.9 Large Service Valve Actuators

Large valve actuators will be electric motorized actuators, using Profibus communication protocol. Small valve actuators for quarter turn valves shall also comply with standard communication protocol.

All valve actuators, whether electrical or manual, will be located either above grade, or if not below a sump or trench flood line, at grade using stem extensions or torque tubes. Chain wheel will not be allowed.

12.5 Pipe Support and Anchors

All major piping systems will be correctly supported by designed pipe support systems. The support design will consider all the external and internal forces that may affect the pipe systems including expansion, seismic, and hydraulic. Pipe supports, guides, hangers and anchors will conform to the appropriate American Society of Mechanical Engineers Code.

The simple beam formula will be used for lines supported by two pipe supports. The two span formulas will be used for lines supported by three or more supports. Stress and deflection calculations will be performed where these spans are exceeded, or where lines have substantial concentrated loads such as valves, unsupported vertical risers, and branches.

Permanent supports will be provided for fixed piping adjacent to piping sections or equipment that requires frequent dismantling for maintenance. Pipe support materials will be selected for compatibility with the chemicals being served.

12.6 Process-Mechanical Equipment

12.6.1 General Design Requirements

Process-mechanical equipment will be based on the technical specifications and datasheets to specify design code, fabrication, operation conditions, installation and testing requirements. All equipment weighing over 50 pounds will be furnished with lifting lugs. All ferrous metal equipment will be shop painted and field painted as required.

12.6.2 Lifting Equipment

Lifting equipment will be provided in new process buildings, as required, to facilitate the maintenance and removal of equipment. Lifting equipment will consist of either a traveling bridge crane or a monorail.

Lifting capacity will be equal to 1.5 times the maximum equipment weight in the building. All top running bridge cranes will be double girder and will be designed according to the Crane Manufacturers Association of America (CMAA) Specification No. 70, Class B. All under-running bridge cranes will be single girder and will be designed according to CMAA Specification No. 74, Class B. All monorail and patented track under hung cranes will be designed to ANSI MH 27.1 Class B.

Duty lifting equipment will be motorized trolley and electric wire rope hoists. In general, according to CMAA standards, the machinery will be equipped with an independent mobile control button all along the bridge with a suspended control cable attached to a rail fixed to the bridge.

12.6.3 Pumps

The pump types will be suitable for the application with respect to flow and head conditions, efficiency, materials of construction, and orientation. Motor horsepower rating will not be less than 115 percent of maximum pump brake horsepower (BHP) accounting for motor efficiency. Pumps with motor sizes 50 hp and greater will be considered for variable speed operation if beneficial to the process or for soft starts.

12.6.4 Tanks

Tanks for chemical storage will be designed to American Society for Testing and Materials or equivalent standards. Chemical storage tanks will be fabricated from reinforced fiberglass with special resins that have demonstrated favorable resistance to chemical solution. In addition, compatible material gaskets will be used at all nozzles. Secondary containment will be provided for the maximum volume of the tank plus fire sprinkler fire flow according to building and fire codes.

12.6.5 Chemical Feed Systems

Chemical feed system equipment, instruments, valves, and piping will be selected for the application. Where turn-down feed requirements exceed 10 to 1, multiple duty devices will be selected.

12.6.6 Secondary Containment

Secondary containment will be provided for the maximum volume of the tank plus fire sprinkler fire flow according to building and fire codes. The floor in the containment area will be sloped towards a centrally-located sump where small nuisance spills and washdown will be collected. The sump will not be provided with a pump but will be connected to the containment tank and will be equipped with a quick connect coupling and pipe to allow for vacuum removal of bulk liquid.

A chemical off-loading pad will be provided to eliminate the possibility of an off-site spill during the off-loading process. The off-loading pad be sized to accommodate the full length of the one truck and trailer. During unloading, spills will be directed to a separate containment tank that will accommodate the full 20,000 L chemical delivery plus an additional 5,000 L buffer volume.

12.6.7 Compressed Air

Dry, oil free compressed air will be supplied to the chemical unloading panel and the soda ash filters from the existing dual stage compressor and spare receiver tanks at 30 psi and 100 psi, respectively. The existing compressor will be relocated from the breezeway to a repurposed room as part of a new dedicated unloading air system.

13. Building Mechanical Design Criteria

13.1 Overview

This section presents general information related to the building mechanical design criteria for both the WTP and the RWPS, including references and guidelines to used in the design and the types of systems and materials for:

- Heating ventilation and air conditioning (HVAC)
- Fire protection
- Domestic plumbing
- Drainage

13.2 Heating Ventilation and Air Conditioning

The design of HVAC systems for each occupancy climate zone shall be based on its use and occupancy. There are two main area types: those assumed to be normally occupied, such as offices, change rooms, public areas etc.; and those for which the main use is for process and related equipment, and therefore are occasionally occupied. HVAC systems for occupied areas and areas for process and related equipment are to be separate from each other.

HVAC systems are to be designed in accordance with the BC Building Code, WorkSafeBC, NECB, and ASHRAE standards, including energy efficiency requirements. Environmental design conditions for Comox Airport are to be used.

All areas within the facilities that require HVAC systems shall be designed in accordance with noise criteria set out in ASHRAE. In areas that do not have applicable ASHRAE requirements, noise control measures such as silencers and insulation will be designed and installed to reduce levels as suggested by best practices. Interior and/or exterior insulation may be used to help minimize noise transfer into occupied spaces.

All areas considered as occupied, shall receive outdoor air at a ventilation rate and quality class appropriate for its occupancy category per ASHRAE standards. Supply air will be delivered to each occupied space by equipment such as air handling units (AHU's), heat pumps or heating recovery units (HRV's).

HVAC systems will be designed assuming a summer cooling set point range of between 20 - 24 degrees Celsius, and a winter heating set point of 18-22 degrees Celsius. HVAC equipment shall also provide for free cooling.

Equipment such as AHU's, heat pumps and HRV's used for providing supply air to occupied areas and occasionally occupied areas will be selected such that they are capable of maintaining ventilation, temperature and humidity to each zone individually. Equipment will be installed in locations so that they are easily accessible for routine and scheduled maintenance, and so they do not interfere with any other equipment. Equipment selection will take into account the need to provide an acceptable level of redundancy to the HVAC system. Each area will have a thermostat to control the temperature separately from other areas.

13.2.1 Energy

With consideration given to the ease of installation and future servicing, it is expected that all equipment will be operated using electrical power.

13.2.2 Ducting

Supply and return air in occupied spaces will be delivered by galvanized steel overhead ducting. Supply and return air in occasionally occupied spaces will be delivered by stainless steel, aluminum, fibreglass reinforced plastic (FRP) or PVC ducting. Duct material and installation method is to be resistant to corrosion and robust enough for installation in an industrial setting. Ducting and insulation is to be designed and installed per ASHRAE and SMACNA standards, and is to be supported as needed for seismic restraint. Fire dampers will be used to maintain fire separations.

13.2.3 Special Design Areas

There are areas within the facility that will require special design consideration for HVAC. Each of these areas will have HVAC systems designed to meet the specific codes, process equipment requirements and functional needs of that individual area. Areas that have special HVAC requirements include, but are not limited to the following:

Location	HVAC Requirement
Lunch Room	Extraction air (range fan)
Wet Lab	Extraction air (fume hood is not required)
Control Room / Offices	Dedicated heat pump split system or hot water radiant heat
Process Areas	Additional air for equipment as required
Electrical Rooms	Dedicated air conditioning system for heat generated from electrical equipment, humidity control
Chemicals Storage	Increased ventilation rate (extraction fans) Areas to have negative pressure

13.3 Fire Protection

The design of all fire protection systems will be undertaken by a designer that is familiar with the British Columbia Fire Code requirements and of the general requirements of equipment and processes in an industrial setting. All elements included in the design of the fire protection system are to be reviewed and signed off by a fire protection engineer registered in the province of British Columbia.

Components to the fire protection system may include, but are not limited to the following:

Fire Protection Element	Requirement
Site Fire Pump	To meet the demand as set out in Section 8.3.4.3
Siamese Connections	Located near building entrance
Water Supply from hydrants	Complete with dedicated pumping if required
Fire Extinguishers	Located in each room, specific to Zone requirements
Annunciators	Located as required
Smoke Detectors	Located as required

13.4 Domestic Plumbing

Domestic plumbing systems are to be designed to meet the BC Plumbing Code. All hot and cold water piping is to be insulated. Potable water will be supplied by domestic plumbing system to fixtures in the occupied areas of the facility, and to any equipment such as emergency showers, eyewashes, showers and drinking water fountains located in unoccupied areas.

A booster pump system, including a standby pump, will be used to provide the required flow and pressure conditions to the domestic water supply from the clearwell. Piping for the domestic water system will be copper or stainless steel.

The system will be designed such that the water supply for all potable water fixtures is separate from all non-potable equipment connections. This separation shall be accomplished using backflow preventers. Backflow preventers are to be selected, installed and tested per CSA B64.10. The potable water system is to be protected from contaminants in accordance with all relevant codes, and in a manner that is satisfactory to the health authority.

Non-potable water will be supplied to equipment and fixtures in the process areas of the facility.

Hose bibbs and standpipes located outside of the heated portion of the building are to be frost free, self-draining fixtures, or insulated and heat traced.

Hot water will be provided to the potable water system using commercial grade hot water tanks located in the mechanical room or other suitable location. Tanks are to be selected to provide, at minimum, hot water adequate for the demand of the emergency shower and eye wash plus demands for domestic uses. If a hot water supply is required for the non-potable system, that system will have a dedicated hot water tank(s).

An emergency shower and eyewash shall be installed in the chemical storage area. An emergency eyewash shall be installed in the laboratory. Emergency equipment are to come with flow limiting valves, thermostatic mixing valves and flow switches to be used for alarming. Additional emergency equipment may be required based on the final design and layout of the system. The location, selection and installation of all emergency showers and related equipment is to be meet the requirements set out by WorkSafeBC and ANSI Z358.1.

13.5 Drainage and Sanitary

Drainage and sanitary piping systems are to be designed in accordance with the BC Plumbing Code.

Trap primers are required for all traps.

13.5.1 Storm Drainage

Runoff water from the roof will be conveyed to the storm drainage system. Downspouts and storm drain are to be sized per British Columbia Plumbing Code.

13.5.2 Domestic Drainage

Floor drains are to be sized for the expected flow. Funnel floor drains are to be installed where equipment discharges water via small diameter pipe or tubing. All below floor piping is to be serviced by well-located cleanouts of the same nominal size. Pipe is to be DWV or cast iron, except where corrosive materials may enter the system. If corrosive materials may be present, and for all downstream piping, corrosion resistant piping is to be used. Drains are to be protected from return flow and gases with trap primers.

13.5.3 Domestic Sanitary

Sanitary drainage is to be sized per plumbing code. Fixtures are to be protected from backflow of fluid and gases by trap primers and backwater valves.

14. Electrical

14.1 General

The following subsections outline electrical design criteria for basis of sizing and preliminary design. In general, a high level of redundancy will be provided.

14.1.1 Design Criteria

The electrical system and electrical equipment must provide the highest level of safety and functionality, and must incorporate the principles of environmental safeguards, protection of the process equipment, economy of operation in all regards, and high reliability.

Table 14-1: Design Criteria

Utility Secondary Service:	600 V, 3 Phase, 4 wire, 60 Hertz, resistance grounded system.
Backup power generators:	600 V, 3 Phase, 4 wire, 60Hz, resistance grounded system
Equipment Voltage Ratings:	
- AC Motors < 1/2 HP:	120V 1 Phase 60 Hertz
- AC Motors 1 HP – 500 HP:	575 V 3 Phase 60 Hertz
Lighting:	
- LED:	120 VAC
- Metal Halide if LED is not available:	120 VAC
Hig- h Pressure Sodium if LED is not available:	120 VAC
Control Voltages:	
- Discrete:	120 VAC or 24 VDC
- Analog:	4-20 mA
- Fieldbus (e.g. HART, Profibus or Modbus TCP/IP)	0-30 VDC

14.1.2 Building Power Requirements WTP

The electrical power requirements at the water treatment plant will be based on the power demand of process pumps, process motors, building HVAC, lighting, general power, and process valves.

Based on preliminary load calculations of the pressurized membrane WTP systems, the total connected load of the facility will be approximately 1800 kVA and the estimated operating loads would be approximately 1500 kVA, all including the building loads. A 25kV-600 V unitized substation with the capacity of 2000 kVA will provide normal power and allow some future expansion to the facility. Two 750 kW standby generators will be required to provide full backup of the WTP facility.

The submerged membrane WTP system will have less power demand and the estimated total connected load will would be approximately 1200 kVA and the estimated operating loads would be approximately 1000 kVA, including all building loads. A 25kV-600V unitized substation with the capacity of 1500 kVA will provide normal power and allow some future expansion to the facility. Two 500 kW standby generators will be required to provide full backup of the WTP facility.

The following pump motors have been identified as being required to be operated with Variable Speed Drives:

- Flocculation Mixers
- Permeate pumps
- Backwash pumps
- Spent Filter Backwash waste pumps and
- CIP pumps

14.1.3 RWPS

The electrical power requirements at the raw water pump station is estimated based on the power demand of three (3) 250hp pumps (one being standby) and two (2) 200hp pumps, building HVAC, lighting, general power, and process valves. The large vertical turbine pumps (including standby) will operate in parallel and each pump will be individually driven by its variable speed drive (VFD). VFDs will provide a typical speed range adjustment from 50 to 100 percent.

Based on preliminary load calculations, the total connected load of the facility will be approximately 1200 kVA. The estimated operating loads would be approximately 930 kVA, including all building loads.

A 25kV-600V unitized substation with the capacity of 1000/1333 kVA will provide normal power. Two 500 kW standby generators would be required to provide full backup of the RWPS facility.

14.2 Applicable code and standards

The electrical design will conform to the following codes and standards:

- 2015 Canadian Electrical Code
- Canadian Standards Association (CSA International)
    - CSA C22.1-15, Canadian Electrical Code, Part 1, Safety Standard for Electrical Installations
    - CSA C22.2 No. 14-13 Industrial Control Equipment
    - CSA Z462-15, Workplace electrical safety
    - CSA C390-10, Test methods, marking requirements, and energy efficiency levels for three phase induction motors
- IEEE 519-2014, Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
- BC Safety Authority Requirements
- WorkSafe BC Regulations
- All electrical equipment shall bear a factory installed CSA or cUL label, or other certification marks acceptable in the province of British Columbia.

Where applicable, the standards and codes of the following organizations will govern equipment specifications and installations:

- Canadian Standards Association (CSA)
- American National Standards Institute (ANSI)
- Illuminating Engineers Society (IES)
- International Society of Automation (ISA)
- National Electrical Manufacturers Association (NEMA)
- Institute of Electrical and Electronic Engineers (IEEE)
- International Electrotechnical Commission (IEC)
- National Fire Protection Association (NFPA)
- Electrical Equipment Manufacturers Association of Canada (EEMAC)

14.3 Utility Power Supply

The primary Electric Service for the WTP and RWPS will be provided by BC Hydro from their Puntledge Substation at 25 kV, 3 phase, 60 Hertz. BC Hydro will extend the 25 kV overhead power line from the Puntledge Substation to each facility. The CVRD will be responsible for the cost of this 25kV overhead power line extension to each site.

14.4 Electrical Power Distribution

Due to the criticality of these new facilities, the electrical power systems will be designed with high reliability to minimize power interruption and unplanned power shutdown as well as to provide safe operation and maintenance for the operations personnel.

The electrical power distribution design will involve some complexities and will allow for maintenance of the switchgear, generators, and MCCs while maintaining full or partial operation of the facility. In the detailed design, the loads will be studied and calculated in detail and sizing of the electrical equipment including standby generators will be confirmed.

The basic configuration of the power distribution system will be a standard radial system with a single primary 25 kV, three phase, three wire power supply provided by BC Hydro. The incoming 25 kV voltage will be transformed down to 347/600 VAC three phase, four wire secondary power by an oil-cooled transformer.

Incoming power from the new BC Hydro primary line will be routed underground to the new unitized substation at each site. The unitized substation will be owned and operated by the CVRD. Each unitized substation will consist of BC Hydro incoming primary section, step down transformer, and a main disconnect switch. BC Hydro metering will be metered at the secondary voltage.

A low voltage switchgear will be provided with main service entrance circuit breaker, BC Hydro utility metering equipment (CT/PT), Surge Protection Device, Feeder Breakers to each Motor Control Centres (MCC) and a digital power quality monitoring (PQM) device.

The PQM will monitor the facility Voltage, Current, Power, Power Factor, Power Harmonics, etc. The PQM will be connected to the facility SCADA control system via a digital bus communication for remote monitoring, alarming and recording.

The Motor Control Centre (MCC) will be provided in two MCCs with split load configuration, such that one MCC can be completely shutdown for maintenance while the other MCC will provide the facility half load requirements. Each MCC will include Automatic Transfer Switch (ATS), Power Quality Monitor (PQM), motor starts and feeder breakers.

Motors, valves and HVAC systems will be strategically connected to the two 600V MCCs so that maintenance can be performed on one MCC at a time. Each MCC will be individually connected to the switchgear via a dedicated automatic transfer switch (ATS).

A 600-208/120V dry-type transformer will feed a 225A 208/120V 3Phase 4W panel board for Lighting and general power. This transformer will be connected to both of the MCCs via an ATS such that lighting and general power is available during utility outage as well as scheduled maintenance. Building loads and other non-essential loads will be fed from this panel.

14.5 Backup/ Standby Power Systems

Each facility will be equipped with redundant diesel fueled power generators as a backup power supply. Each generator will be sized to supply a minimum of the half of the facility operating loads.

Each generator will be housed in a custom walk-in weatherproof and vandal resistant enclosure with sub-base dual walled fuel tank. The sub-base fuel tank will be sized to allow 24 hours of backup power operating time at full load. Fuel transfer will be from a fuel delivery truck equipped with a transfer pump and heavy duty rubber hose terminated with a heavy duty pistol grip nozzle.

Genset overall full load operating noise will be less than 79dbA when measured at a distance of 6 meters from any side of the enclosure, 1 meter above ground.

In addition to hardwired discrete status and alarm signals (Running status, Warning alarm and Shutdown alarm) connection to the facility control system, digital monitoring of the genset parameters will be provided and connected to the facility control system Modbus/TCP or Ethernet/IP network.

The generators will be connected to a generator paralleling bus that feeds to each Motor Control Centre (MCC) via a dedicated automatic transfer switch within the MCC.

The automatic transfer switch will detect a loss of power, start all the available generators and then transfer the loads to the generator. The facility control system will continuously monitor and evaluate the running loads and then decide if a single generator would be sufficient to run the facility. If the operating loads is lower than a single generator capacity, a generator will be shut down. If the load demand is increasing, the standby generator will be started and synchronized to the genset bus.

After utility power is restored, the automatic transfer switch will retransfer the running load to the utility power, and then shut down the genset after a suitable cool down period. The transfer switches will be open transition type such that on the retransfer to the utility, there will be a second short power interruption about 5 to 10 seconds.

A load bank connection junction box will be provided on the outside wall of each building. This will facilitate a quick and convenient connection to a portable resistor load bank for preventative maintenance purpose without disconnecting the fixed generator connection cabling. As recommended by genset manufacturer, at least every two years, the generator will need to be run at full load to ensure that the generator is able to produce the maximum load when required. Lightly loaded generator will develop wet stacking and carbon build-up in the combustion chambers and exhaust systems due to that the engine does not reach the proper operating temperature. The load bank testing will also help cleaning the combustion chamber from carbon build-up.

Note if desired, load bank can also be permanently installed and connected to the generator paralleling bus to automatically regulate the required genset minimum running loads which is typically 30% of the generator capacity in order to avoid or reduce significantly the effect of wet stacking. The installed load bank can also be used to exercise the generator monthly testing without interrupting the facility running loads.

14.6 Grounding system

The secondary 347/600V power system will be equipped with a high resistance grounded system (HRGS) that will limit the ground fault current to 5 or 10 Amps. The HRGS applies to both when either power is supplied from BC Hydro or standby generators.

With the HRGS, the facility can still supply power on a single ground fault, until such time that the affected area of the fault can be scheduled to be shut down and corrected.

Monitoring of the integrity of the of the HRGS is important that damage to the integrity of the HRGS will result in an undesirable ungrounded power system. Monitoring of the HRGS will be included in the design requirement. Alarm output will be send to the facility control system.

120/208V power distribution will be solidly grounded.

14.7 Motor Starter Systems

Motor starters will be provided with Across the Line Starters (ACL), adjustable variable speed drives (VFD) or solid state soft starters (SSS) as required. SSS and VFD permit pump motors smooth pump starting and stopping. Additionally, the VFD will allow the pumps to operate at variable speed.

All motors below 50HP will be started utilizing Across the Line Starters (ACL) and motors 50HP and larger will be equipped with Solid State Soft Starters (SSS) to reduce the motor inrush starting currents. For specific applications where motor speed needs to be varied, adjustable variable speed drives will be utilized.

Pump starters will be installed in the MCC compartment. Larger VFD pump starters will be installed in standalone enclosure. Pump starters will include the following:

- Motor circuit protector (MCP) or Circuit Breaker. This MCP will also permit locking and tagging out of the motor for maintenance purposes;
- Elapsed hour meter;
- Hand-Off-Auto selector switch;
- Running, Standby and Drive Fault indication lights; and,
- VFD or SSS Keypad.
- Monitoring devices as required.

The starter status and controls will be hardwired to the station control system as follows:

- MCP tripped
- Pump Running
- Fault
- Overload
- H-O-A selector switch Not In Auto
- VFD speed reference

- VFD speed feedback
- Start and stop signal

Motor current and other VFD/ SSS diagnostic information will be monitored through the VFD or SSS Modbus/ TCP or Ethernet/IP connection to the facility control system.

14.8 Variable Speed Drives

Variable Speed Drive will be PWM type, sized for continuous output amperage rating at least 20% in excess of the full load current rating of the driven motor. Each motor will have its own VFD. Connecting multiple motors with one VFD will not be accepted.

To mitigate power system harmonics associated with utilizing VFD, 18 pulse Drives or 6 pulse drives with a single passive harmonic filters or combination of both for each bus or MCC will be specified.

All 600V VFDs will have load side dv/dT filters to protect the connected motors from voltage spikes and rapid voltage rise time.

14.9 Motors

Motors will be horizontal solid shaft or vertical solid shaft squirrel cage induction motors design B with class F insulation (155°C) with Class B temperature rise (90°C) per latest EEMAC standards. All motors rated from 1 to 500HP shall at a minimum meet the Provincial Minimum Efficiency Standards.

All motors utilized with variable speed drives or solid state starters will meet NEMA MG1, Part 31 inverter duty requirements.

Motor enclosure will meet EEMAC TEFC design standards, suitable for operation up to 40°C ambient.

14.10 Electrical System Quality and Reliability

600V power factor correction capacitor banks with harmonic filters will be included to maintain the overall power factor to 0.95 or better, and will be designed to mitigate voltage and current harmonics in the distribution system.

In the event of utility normal power loss, standby generators will provide power for the complete facility including:

- Emergency and exit lighting
- Emergency ventilation
- Freeze protection as required
- Selected motorized valves and solenoids, including all filter control valves

Uninterruptible Power Supply (UPS) with 1hr run time batteries and a maintenance bypass will be included to provide redundancy to service the critical loads including:

- Life safety systems (such as fire alarms, panic buttons, or emergency shower)
- Security systems
- Plant control and communications systems
- Key process monitoring instrumentation
- Emergency isolation valves related to plant overflow protection

14.11 Energy Efficiency

Energy efficient equipment such as Motors, transformers, lighting etc. will be specified for the new WTP and RWPS facilities.

14.12 Lighting and Receptacles

Energy efficient LED light fixtures will be utilized for the facility and operated manually by a wall switch located inside each room next to the door.

Fully automatic emergency lights will be provided c/w main battery pack unit and rated for a minimum one hour system operation. Exit lights powered from the 120VAC panel will also be provided.

Exterior lighting will be LED Wall Pack with photocell mounted on the exterior of the building, controlled by a Hand-Off-Auto switch located inside the building near the entrance. In Automatic mode, the lights will be controlled by the photocell.

Site lighting will be provided by using davit light poles with LED light fixture with photo cell at the main gate and as required.

IES Lighting levels will be used as a guide and generally the lighting levels would be as follows:

- Electrical rooms, process area, mechanical rooms 400 lx
- Outdoor area lighting 10 lx
- Offices 1000 lx

Convenience wall receptacles will be provided throughout the facility with minimum one duplex receptacle in each room. All wall receptacles will be fed from power distribution panel circuit breakers, and where required by the Code, GFI circuit breakers will be provided.

14.13 Lightning Protection Systems

Lightning risk analysis will be provided in accordance to CAN/CSA-B72-M87 to determine the building requiring protection.

14.14 Telecommunications System

14.14.1 Fibre Optic Site Communication

A redundant dedicated fibre-optic communication trunk will be provided between the WTP and the RWPS. It will support the communication between the WTP and the RWPS for process control as well as the telecommunication requirements. A redundant dedicated fibre-optic communication trunk will also be provided between the WTP and the rest of the CVRD communications network. It will transmit key water quality and facility operating values as well as the alarms and telecommunication requirements.

14.14.2 Radio Communication

An antenna and communication system will be included at the WTP for redundant emergency communication via radio in the event fibre-optic communication is interrupted. The antenna and radio system will communicate with the existing CVRD wireless network with the nearest link being the West Courtenay Tower that has tripled wireless connection to CVRD head office. Radio towers are provided by North Island Communication. From West Courtenay Reservoir, radio system supports communication to rest of CVRD system and external world using a CVRD owned 23.8 Ghz channel.

14.14.3 Telephone System

A telephone conduit system will be provided in the in the electrical room. Telephone to outside will be over the fibre-optic communication line. As a minimum, three phone lines will be provided. Plan is to have multi-fibre service between WTP and the West Courtenay Reservoir. CVRD will own and maintain the buried fibre line. BC Hydro will not permit hanging the fibre (since not a telecom company). Fibre within the plant will support the following networks:

Network	Type
Telephone (VOIP)	V-LAN
SCADA	V-LAN
Corporate LAN	V-LAN

14.15 Fire Alarm System

Pull stations and combination horns/light signal devices will be provided for the WTP. Smoke detectors will be provided for the electrical rooms, control room, offices, and laboratory. A fire alarm control panel will be provided in the office main lobby.

14.16 In-Plant Communication System

Communication between operations and maintenance staff within the plant will be provided as a two way radio system or other dedicated, secure, and portable communication system.

14.17 Intrusion Alarm, Access Control and CCTV Systems

Building security intrusion alarm system will consist of alarm secure panel (i.e. DSC) that will monitor door or intrusion switches, batter back-up power and keypads. This alarm panel will be connected to a dedicated public telephone system. Currently, CVRD contracts the “Price’s Alarms” security alarm company in Victoria for the alarm monitoring. Alarm call outs will be directed to “Price’s Alarms” and then they would page RCMP or CVRD or both.

CCTV surveillance system will be provided for monitoring outside area of the facility. CCTV will be PTZ cameras and POE capable and provided with a stand-alone surveillance monitoring system.

14.18 Electrical Power Study

A comprehensive power study for the electrical system will be provided. This will include short circuit study, protection and coordination study, power flow, harmonic study and arc flash hazard analysis. Recommended using the EasyPower power system study software.

15. Instrumentation and Controls

15.1 General

Instrumentation and controls will be provided to monitor and control the raw water pump station and water treatment processes. The development will consider the process safety, redundancy and long term operation and maintenance, calibration of the instruments.

15.2 Field Instrumentation

Field instrumentation will be provided. For field device communication, 4-20mA devices with digital communication protocol (such as HART or Profibus) are proposed for the all field devices, where supported by the devices. Field devices connections will be via field junction boxes close to the devices to reduce the amount of field wiring.

Where conventional I/O are more appropriate, conversion from discrete to fieldbus will take place at field junction boxes to reduce the amount of field wiring.

Instrumentation will be selected for proper operation and the working environment where the instrument is installed. For commonality, all instrumentation of similar functionality will be from the same manufacturer throughout.

15.3 Process Control System

Programmable Logic Controllers (PLCs) will be utilized to control the RWPS and WTP. All instrumentation, field devices and control devices, such as pressure transmitters, flowmeters, and control valves will be interfaced with the PLC input output (I/O) modules for process control, alarming, monitoring and automation.

Digital communication for the various motor starters, VFDs, power quality monitoring, genset or UPS will be provided by Modbus TCP or Ethernet/IP communication. This communication will be for monitoring only. All controls for the motor starters or VFDs will be hard wired to the controller local I/O modules.

15.4 Control System

This section describes and establishes the instrumentation and control (I&C) systems design approach for the Project. Topics addressed include applicable standards; SCADA background, system-wide improvements, and system requirements; control system requirements and architecture; data reporting and logging; information sharing; transition planning; and telecommunications and security.

15.4.1 Plant Process Area Designations and Tag Systems

Control system inputs and outputs (I/Os) will reference the equipment by its tag number. This number will also appear on P&IDs, location drawings, schematics and loop drawings.

15.4.2 Control System Architecture

The overall plant architecture will be designed so that there is no single point of failure (e.g. use of a redundant systems). Redundant controllers will be used at the main control panel. Local I/O modules or remote I/O modules will be provided. The field instrument will be strategically connected to the I/O modules such that failure of one I/O module or instrument will not hinder other process trains connected to other modules.

One generator workstation at the WTP and one operator HMI at the RWPS will be provided which will communicate over a redundant fibre optic network connection. A secondary workstation will be provided as a backup to the primary workstation in the WTP. The secondary workstation will also function as the engineering software development workstation. This will minimize the network traffic for the primary workstation.

The facility main PLC control system and other control systems will communicate over redundant copper or fibre network to the SCADA workstations.

Acceptable vendors for the process control systems and SCADA would be Delta-V control system, Allen Bradley Control Logix Control system with ClearScada for the WTP and the RWPS. Software stack currently used is OSI Soft PI historian with middleware and Rockwell Factory Talk.

Within the WTP, the use of HMI's will be limited to specialized vendor equipment (e.g. the UV disinfection system) or to major process areas separated from the operations building, in which case the HMI will be provided within a local control panel.

One additional computer workstation in the office and one in the lab will allow the use of CVRD enterprise software and network access.

WTP process alarms will be sent out via an analog telephone dial out system or email. The RWPS process alarm will be communicated to the WTP control system via redundant fibre optic Ethernet communication network.

A colour printer will be connected to the control room terminal router. A second printer will be dedicated to alarm/event and acknowledgement functions.

Proposed control system architecture and plant network for the RWPS and WTP is shown on sheet E-0001.

16. Commissioning Requirements

16.1 Overview

This Section generally described the content and general requirements for successful commissioning of the Primary Infrastructure (Raw Water Intake and Pump Station, and the new Water Treatment Plant).

The commissioning and initial operations, start-up, and testing will be carried out by the successful Proponent in accordance with the specified criteria provided in the RFP. As defined by the requirements of RFP and generally described below, these activities will generally include:

a. Pre-Commissioning,
b. Unit Process Commissioning,
c. Integrated Process Commissioning, and
d. Performance Trial.

Commissioning requirements for specific unit processes or equipment will be described in the detailed Technical Requirements where the process or equipment are specified.

The sections below also include a description of the reporting and submission requirements for the Commissioning Phase. As used in this section, the following definitions have the noted meaning:

- “Commissioning Plan” means a written document, prepared by the Proponent, describing all post-construction activities that will be carried out to bring the Primary Infrastructure into service and supplying the District with treated water meeting the Technical Requirements.
- “Commissioning Phase” means all activities between construction and operation.

The detailed testing processes, procedures, sequencing and schedule to demonstrate the ability of the Primary Infrastructure to meet the detailed Technical Requirements outlined in the RFP will be set out in a detailed Commissioning Plan submitted by the Proponent in advance of the schedule activities.

The Commissioning Plan will be reviewed by the Owner’s engineer and the Owner for compliance with the RFP and the Owner’s requirements.

16.2 Start-Up

The requirements of Start-up within the Commissioning Plan will outline the approach and activities to confirm that the various components of the Primary Infrastructure are correctly installed and in full compliance with the Proponent’s Design and the intent of the Technical Requirements.

The pre-commissioning Start-up Plan will indicate the proposed methods to test the various components of the Primary Infrastructure and will generally include requirements for:

a. Water tightness testing and disinfection.
b. Calibration of instrumentation.
c. Operational testing of all mechanical equipment.
d. The proposed method, rate and duration of introducing water to the WTP during the testing and the proposed disposal method for water used.
e. Electrical circuit testing.
f. Verification of local controls.
g. Verification of operating parameters (e.g., pressure, voltage, temperature, vibration, etc.).
h. Testing of PLC and SCADA system operation.

16.3 Unit Process Commissioning

The requirements of Unit Process Commissioning within the Commissioning Plan will outline the approach and activities that demonstrate the ability of the equipment and facility to run for an extended uninterrupted period of time (minimum of 3 days) with no unplanned maintenance or operational intervention.

The Unit Process Commissioning Plan for the Primary Infrastructure and will generally include requirements for:

a. The proposed method, rate and duration of introducing water into the WTP and a plan for disposal of the water produced.
b. Wet and dry run performance tests.
c. Monitoring of PLC and SCADA logic operation.
d. Monitoring of operation of all equipment in the facility.
e. Optimization of chemical dosage rates.
f. Tuning of control system settings and process set points.

The Commissioning Plan will include for a period of initial operation, adjustment and system balancing as required to bring the system into stable operation. No water from the facility will be allowed to be directed to the District's distribution system during the Commissioning Phase. Disposal and handling of all water used for commissioning will be the responsibility of the Proponent.

16.4 Integrated Process Commissioning

The Integrated Process Commissioning will be performed after Unit Process Commissioning and will demonstrate that the facility produces water, uninterrupted, for a period of 7 consecutive days

The requirements for the Integrated Process Commissioning within the Commissioning Plan will generally include the following provisions:

a. Test each raw water pump individually up to 100% of the rated capacity.
b. Test each process train and individual filter up to 100% of hydraulic or rated capacity for a continuous duration.

The plan will indicate whether the Proponent intends to supply water to the District's distribution system during this period.

16.5 Performance Trial

A 30-day Performance Trial requirement will be specified following completion of the Pre-Commissioning, Unit Process Commissioning and Integrated Process Commissioning phases.

This will generally include advance submission and acceptance of:

a. Reporting requirements.
b. Start-up and testing logsheets.
c. Commissioning documentation.

The Performance Trial shall demonstrate that the facility is able to operate reliably for 30 consecutive days without unplanned maintenance or other unplanned operator intervention.

The Proponent will be required to update the Plant Testing and Initial Operations Report with information from the Performance Trial and submit the report to the District for review

16.6 O&M Manuals

The requirements for the O&M Manuals will require submission in both electronic PDF and hard copy form. The O&M Manuals will be required to include all necessary requirement for operation, maintenance and rehabilitation of the equipment and infrastructure.

The O&M Manuals will be reviewed and delivered to the District prior to and as a condition precedent to Substantial Completion of the Primary Infrastructure.

17. Site Security

17.1 Overview and Philosophy

A water treatment plant presents a series of different challenges and requirements unique amongst local authority assets. These include easy access to the plant, materials and equipment; and the potential for objects/substances to be thrown into the treatment system from outside of the plant. Also in this instance potential for recreational hunters inadvertently or deliberately discharging a fire arm into the compound.

The buildings and structures shall play a role in providing security of the facilities in their placement whilst maintaining ascetics and functionality. Careful consideration should be given to the location and physical construction of buildings and structures to enhance the security through masking sensitive or vulnerable plant equipment.

To protect the public from injury from plant equipment, or the potential for downing within an exposed tank, a perimeter fence shall enclose both compounds.

The proposed security design for the WTP and RWPS building will consist of a combination of physical and electronic measures which provide a secure perimeter to detect / deter intruders yet allow free access for staff throughout the interior of both facilities. Intrusion detection system will protect the building interiors out of normal working hours and will be integrated with the perimeter access control system to provide total protection for the site.

Additional perimeter protection will be provided by CCTV surveillance of the buildings and compounds. Cameras shall be situated to provide recordings of movements to and from the buildings. Cameras shall also be situated appropriately to provide surveillance of sensitive and/or venerable equipment located with the compounds.

17.1.1 Water Treatment Site

The WTP site is near multiple walkway and biking trail networks and is planned to enhance those amenities with parking, a public washroom, and a water station.

Since the WTP will function as a publicly accessible facility during work hours for the purpose of hours, as well as a shared site for public trail use with public parking, the security philosophy will have to accommodate a balance of being both welcoming at areas used by the public and fully secure.

The security measures should be subtle and muted in their appearance to be consistent with a welcoming theme.

17.1.2 Raw Water Pump Station

The RWPS site is adjacent to a logging road and near a private campground on one side and non-authorized but known public gathering area (after-hours) on the other side. Signage in the area has evidence of small fire arms discharge.

Given the utilization function of the building and evidence of small fire arm discharge, the philosophy for the RWPS will be of an elevated and hardened security approach.

17.2 Building Orientation and Layout Considerations

The first aspect of the building shall be the construction. The RWPS building should have no windows and/or vents visible from the perimeter of the compound. The building materials selected shall be resistant to gross attack and/or possibly low calibre centre fire ammunition, preferably concrete.

Where practical all electrical panels, electrical transformers, electrical standby generators, fuel tanks, and any other sensitive equipment shall be contained within a standalone structure separate from the main facilities (WTP and RWPS). Where plant equipment is required within the compound it should be screened from view from the perimeter of the compounds by structures within the compound. It is recommended for transformers and fuel tanks especially, if a structure is unable to prevent direct visibility from the perimeter, a suitable concrete wall is utilised.

All external doors to any building should be solid wood construction with a 1.2 mm steel skin minimum.

Situate any open tank well within the compound perimeter fence limiting the potential for thrown objects entering the tanks.

The RWPS is adjacent to road, situated on a bend. Bollards or concrete barriers should be fitted along the western perimeter fence line as indicated on the site plan, to prevent a vehicle from accidentally or maliciously breaching the perimeter fence line.

17.3 Perimeter Fencing

For the RWPS, the perimeter security system will consist of a complete and fully operational non-lethal commercially available perimeter power fence security alarm system (perimeter power fence). The perimeter power fence security system will function as an active deterrent (delivering a pre-specified safe but painful electric pulse), a physical barrier, and a reliable detection system alerting staff and/or security personnel of an attempted intrusion and its location around the perimeter of the site. The Perimeter Power Fence will be a 2 metre high chain-link fence, with a 2.3 metre high power fence attached on the WTP plant side of the fence (note this is "one fence", not two separate fences). There will be a vehicle gate at the vehicle entry area.

The perimeter power fence security alarm system will be divided into easily identifiable sections or zones for response and audit purposes. Each zone will report via the intrusion security system as an individual zone to the security control room.

For the WTP, a standard security fence will form a perimeter around the back of the site (side opposite the public area). Where the fence is not visible by the public it will be either fitted with a power fence or with barbed wire. At the public area, an open entrance will allow vehicles during working hours and the front of the building will be visible and accessible. The entrance will be closed after hours.

Open space will be used at the entrance so that any unauthorized activity will be visible and in the open. The site with the fence at a minimum distance of 25 metres from the buildings preferably. Pedestrian access is then by an access card control pedestrian gate through the fence.

17.4 Access and Gates

The vehicle gate supplier will provide control of the gate drive (locking, unlocking, motor drive forward / reverse) for the gate, and status sensing of the gate (open, close, locked, fault) for the security alarm system to connect to. The gate will be constructed to the same specification as the perimeter fence. An Access Card reader will be mounted on pillars for both entry and exit.

The pedestrian gates lock will provide status sensing of the gate for the alarm system to connect to. The gate will be constructed to the same specification as the perimeter fence. An access card reader is to be mounted on the entrance to the gate for access into the plant.

17.5 Intrusion Alarm, Access Control and CCTV

17.5.1 Intrusion Detection

The building interiors will be protected by a intruder detector alarm system utilising door sensing and dual technology microwave/passive infrared movement detector sensors strategically placed throughout the plant. In outlying buildings, wireless dual technology sensors could be used.

A keypad will be installed at the main entry of all buildings; exit-entry tones will be enabled on the keypad.

The security alarm system will have battery back-up power so as to resist extended mains failures. The security alarm will be connected to a security monitoring control room to facilitate the appropriate response personnel.

Internal and external audible alarm sounders that sound for unauthorised intrusion will be located within the compounds; these will not sound in normal working hours when the intruder detection system is de-activated. The perimeter security system can still be activated during normal working hours if so desired.

17.5.2 Access Control

Main egress doors, vehicle and pedestrian gate shall be controlled and managed by a purpose-built access control system. This will enable persons carrying a valid card or token to transit through any given door by presenting their card.

The access system will interface with the Intrusion Alarm to facilitate alarm arming and disarming, and alarm reporting. Each access door shall provide a report for when it is left in the open position or has been forcibly opened. All access transactions shall be processed locally but provide full management and control at the CWTP master control room.

The access card readers shall be vandal and weather proof, and mounted adjacent to each entrance door, and on easy accessible pedestals adjacent to the vehicle gates entry and exits. Request to Exit and emergency break glass switches will be fitted to provide for a free exit path if required.

All access control locked doors shall be electronic Locks. All other doors will be secured with mechanical key locks.

17.5.3 CCTV

An IP base CCTV system will be installed to provide surveillance of the building (internal and external), and sections of the compound 2 meters (minimum) outside the perimeter fence where applicable.

High Definition (HD) IP Cameras shall be situated within the all building to provide identification and entrances, and additional cameras to provide general over view within the facilities as required. HD IP cameras shall provide identification to all building entrances, and perimeter fence gates. Additional HD IP cameras positioned on internal structures will provide observation of intruders for sensitive equipment such as transformers, generators, and tanks etc. HD IP cameras within the compound will have Infra-Red illumination suitable to illuminate to the field of view of the camera image required.

All CCTV camera video recordings will be stored on a Network Video Record (NVR) contained within the main building connected to a fit for purpose Uninterruptable Power Supply (USP). The NVR shall be accessible from the Comox Water Treatment Master Control room for live viewing and video archive playback via the IP network.

17.6 Site Lighting

The main entrances and perimeter gate lighting should be designed in accordance with national standards to allow safe egress to and from the facility. In the event of an intrusion alarm a signal shall activate additional light within the compound to improve the lighting for video recording and deter would be intruders.

17.7 Public Access Location / Crime Prevention through Environmental Control (CPTED).

It is recommended that the trees and foliage along the perimeter of the Comox WTP (particularly the road fence line) cover to a maximum height of 600 mm out from the fence for a distance of 20 metres. This is to open up the sight lines around the CWTP, making intruders / vandals throwing objects etc. much more vulnerable to being observed from a distance.

Additionally, perimeter signage to be erected clearly identifying the area is Comox Water Treatment property and trespassers will be prosecuted. Also, that it is an offence to throw objects into the WTP, and offenders will be prosecuted.

18. Project Construction Costs

18.1 Overview

This section presents the updated Opinion of Probable Construction Costs for the Comox Water Treatment Project. The cost estimate prepared is considered an AACE Class 3 or Canadian Construction Association Class B estimate with an accuracy of +15% to -10% based on the development of design.

The cost values have been prepared from the information available at the time of the estimate. The updated cost estimate is shown alongside the cost estimate from the Project Definition Report (PDR) in 2016 to illustrated any variations as the design has progressed. The final cost of the project will depend upon the actual labour and material costs, competitive market conditions, implementation schedule and other variable factors. Therefore, the final project costs may vary within the assumed accuracy. Project contingency is applied as 20% on direct project costs for known unknowns and this level of contingency is considered low but acceptable. Project funding must be carefully reviewed prior to making specific financial decisions.

18.2 Capital Cost Assumptions and Methodology

18.2.1 Assumptions and Exclusions

The estimate assumes the work will be done on a competitive bid basis and the contractor will have a reasonable amount of time to complete the work.

18.2.2 Direct Cost Methodology

Where possible, quantity takeoff was completed for all elements shown in sufficient detail in the design drawings or described. Where possible, vendor estimates were obtained for elements. For all items known to exist but not defined in the project drawings, allowance was applied using experience and values from past projects.

18.2.3 Indirect Cost Methodology

CVRD indirect costs are for internal project management and support and include quality assurance testing, staff costs, permits/fees, building furnishing, lab equipment, insurance, spare parts, signage, safety equipment, related vehicles, and commissioning. All internal costs are based on percentages of the project subtotal.

Indirect costs which are carried by the general contractor include general conditions, mobilization, demobilization, bonding, overhead and profit, environmental protection systems, third party material testing, and have been included as single line items as they apply to all direct costs.

18.3 Opinion of Probable Capital Costs

Table 18-1 presents the opinion of probable construction costs by major areas.

Table 18-1: Opinion of Probable Construction Costs

Item Description	2016 PDR	2017 IDR Direct Filtration	2017 IDR Membrane Submerged	2017 IDR Membrane Pressure
Raw Water				
Intake and Marine Pipeline	$4.94	$5.322	$5.322	$5.322
Pump Station	$4.68	$5.472	$5.472	$5.472
Water Treatment				
Site Works	$1.80	$4.142	$3.507	$3.947
Buildings (Operations)	$10.51 [c]	$4.727	$4.788	$4.510
Pre-Treatment/Coagulation	$0.63	$1.186	$1.186	$1.186
Flocculation	$0.79	$1.120	$1.120	$1.120
Filtration	$7.81	$12.100	$21.642	$21.616
Backwash Equalization	$0.62 [a]	$1.477	-	-
Backwash Treatment	$0.62 [a]	$1.568	-	-
Residuals		$2.956	$2.856	$2.856
Primary Disinfection (UV)	$1.57	$1.840	-	-
Residual Disinfection (Chlorine)	$1.55	$0.263	$0.263	$0.263
Clearwell	$4.77	$6.523	$6.523	$6.523
Pipelines				
Raw Water Pipeline	$5.53	$5.458	$5.458	$5.458
Treated Water Pipeline	*$11.93* [b]	$14.930	$14.930	$14.930
Tie-In	$0.70	$0.450	$0.450	$0.450
Sewer / CIP Waste	$2.44	$0.030	$0.350	$0.350
Subtotal – All Direct Cost	**$60.92**	**$69.57**	**$73.87**	**$74.00**
Contractor Indirect Cost (10%)	$6.09	$6.956	$7.387	$7.400
DB Engineering (6%)	-	$4.174	$4.432	$4.440
Contingency (20%)	-	$13.913	$14.774	$14.801
Contingency (30%)	$18.28	-	-	-
Subtotal - Construction Cost	**$85.29**	**$94.61**	**$106.45**	**$100.65**
Indirect Costs				
Land Cost - PS	$0.40	$0.700	$0.700	$0.700
Land Cost - WTP	$0.50	$0.600	$0.600	$0.600
Environmental Assessment & Water License	$0.20	$0.112	$0.112	$0.112
BC Hydro Service Extension	$1.50	$1.750	$1.750	$1.750
CVRD Indirect Costs (4%)	$3.41	$2.040	$2.040	$2.040
Engineering and CM (15%)	$12.79	-	-	-
Engineering and CM (5%)	-	$3.220	$3.220	$3.220
Escalation to mid-point (8%)	$1.71	$7.569	$8.037	$8.052
Subtotal - Indirect Cost	**$20.51**	**$15.99**	**$16.46**	**$16.47**
Total Project Cost	**$105.80**	**$110.6**	**$116.9**	**$117.1**

Notes:

a) 2016 PDR carried one line item for “Backwash Systems” which has been split 50/50 between equalization and treatment.
b) Treated water pipeline costs in the PDR were $1.6 million low when compared to TM-4 of the PDR which was $13.50 million.
c) PDR carried filtration superstructure as “building” and is now categorized correctly.

18.4 Construction Cost Variance Analysis

Variance in the cost are present. Generally, the unit prices were adjusted between 1 to 2 percent for escalation and labour market and additional information was available in the drawings for more detail in the costing. Also, costs were better allocated by building area to better reflect the full area costs. The following specific changes in project scope and approach resulted in increases to the cost.

18.4.1 Raw Water Pump Station

The topographic survey showed that previous location of the building encroached on the site. Therefore, the building size was adjusted and the electrical room was moved above the pump area. Secondly, the expectation that the foundation would bear on the bedrock, the excavation volumes were increased. The resulting variance is a 17% increase in the pump station cost.

18.4.2 Site Works

Site works increased the most, or about $2 million. This estimate captured underground utilities and pipelines, accurate excavation and backfill quantities, roads, and fencing which were not captured at the PDR stage.

18.4.3 Buildings, Pre-Treatment, Flocculation and Filtration

An increase was expected based on the addition of the water works office and floor space as well as updates to the architectural programming and the decision to cover and enclose the flocculation and filtration areas. The increase is approximately $3.0 million.

18.4.4 Backwash Equalization and Treatment

This increase is related to the availability of actual sizing, quantities, and scope definition. The $3.0 million for backwash treatment was previously carried under filtration in the previous estimate.

18.4.5 Residuals

The increase is related to the addition of thickeners and a centrifuge building. It is offset by the deletion of a sanitary sewer line between the site and the nearest City of Courtenay manhole which was not supported by BC Hydro. This decision is a net decrease in project cost.

18.4.6 Disinfection

The reduction in capital cost is based on the decision of bulk chlorine instead of on-site hypochlorite generation resulting in a decrease of $1.3 million.

18.4.7 Clearwell

The increase in capital cost is related to the capture of the valves, piping, excavation, and backfill volumes which could be better estimated from the topographic survey.

18.5 Operations and Maintenance Costs

Operating cost as annual costs were developed for each option presented in Table 8-2. Present value is calculated over 30 years at 2.5% interest. Unit operating rates were developed for each of the operating costs as follows:

- Chemical costs are based on quotations from two chemical suppliers.
- Electrical power rate used is $0.15 per kW-hour.
- Labour is based on $65 per hour salary and employment costs.
- Specific equipment replacement costs are based on manufacturer costs.

Table 18-2: Annual Operating Cost Estimates

Item Description	Direct Filtration	Submerged Membrane Filtration	Pressurized Membrane Filtration
Consumables - Electrical Power			
Filtration	45,000	176,000	314,000
Raw water pumping	93,000	93,000	93,000
UV Disinfection	50,000	15,000	15,000
Building Lighting and HVAC	127,000	127,000	127,000
Consumables - Parts			
General Equipment Parts Replacement [a]	220,000	280,000	270,000
Membrane Replacement	-	220,000	250,000
Consumables – Chemicals			
Coagulant	58,000	30,000	30,000
Clean-in-Place	-	40,000	40,000
Filtration Polymers	5,000	-	-
Residuals Polymers	25,000	12,000	12,000
Sodium Hypochlorite	81,000	81,000	81,000
Labour			
Operations - WTP and PS [b]	390,000	390,000	390,000
Maintenance Staff [c]	75,000	75,000	75,000
Solids Disposal	20,000	16,000	16,000
Miscellaneous [d]	50,000	50,000	50,000
SUBTOTAL - Annual Costs	1,070,000	1,442,000	1,600,000
TOTAL PRESENT WORTH	22,395,000	30,181,000	33,488,000

Notes:

a) Assumed as 1% of Division 11 to 16 capital cost.
b) Assumed salary and employment costs for 4 FTE's.
c) Assumed 2 service calls per week at $1,000 per call.
d) Miscellaneous includes variable costs for programming, outside laboratory testing, safety, training, communication, etc.

18.5.1 Staffing Plan

Staff labour is the highest cost of operation – or between one third to one half the cost depending on the treatment technology. Staffing for the WTP was reviewed with CVRD operations. Based on a conceptual shift schedule, a total of five treatment personnel was identified being one EOCP Level IV operator and four ECOP Level II or I operators. CVRD can cross train staff from their water works (distribution) group to treatment and vice versa.

Maintenance staff would be shared between the distribution work orders and the treatment plant work orders.

Appendix A – Golder Geotechnical Report

Appendix B – EXP Geotechnical Report

Appendix C – Change of Works Application

Appendix D – Baseline

Appendix E – TM-5 Flow Update

Appendix F – Direct Filtration Bench and Pilot Scale Study

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