Draft Predesign Report (UPDATE)

Water Intake, Treatment Plant, and Supply Mains

Prepared for

Englishman River Water Service

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Acronyms and Abbreviations

°C	degrees Celsius
µg/L	micrograms per litre
µm	micrometre
AC	alternating current
AFD	adjustable frequency drive
AO	aesthetic objective
AOs	aesthetic objectives
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASR	aquifer storage recovery
AWWA	American Waterworks Association
b/w	backwash
bgs	below ground surface
BMPs	best management practices
BPP	back pulse pump
$CaCO_3$	calcium carbonate
Cat	Category
CCT	chlorine contact tank
CCTV	closed-circuit television
CEB	chemical-enhanced backwash
cfu	colony-forming unit
CGA	Canadian Gas Association
CIP	clean in place
CO_2	carbon dioxide
CoP	City of Parksville
CSA	Canadian Standards Association
CWG	community working group
DC	direct current
DMZ	demilitarized zone
ERWS	Englishman River Water Service
ETAPs	ethernet I/P taps
FCL	flood construction level
FF	fireflow

FRP	fibreglass-reinforced plastic
FUS	fire underwriters survey
GCDWQ	Guidelines for Canadian Drinking Water Quality
GST	goods and services tax
ha	hectares
HAA	haloacetic acid
HAAFP	haloacetic acid formation potential
HDPE	high density polyethylene
HLP	high-lift pump
HMI	human-machine interface
HVAC	heating, ventilation, and air conditioning
HVC	heating, ventilation, and cooling
I	inactivation
I&C	instrumentation and controls
I/O	input/output
ICF	Island Corridor Foundation
ICI	institutional, commercial, and industrial
ID	inside diameter
IFE	individual filter effluent
IP	internet protocol
IT	information technology
kg/day	kilograms per day
kPa	kilopascals
LAN	local area network
LID	low impact development
LLPS	low-lift pump station
L/ca/day	litres per capita per day
L/ha/day	litres per hectare per day
LMH	litre per metre squared per hour
LRAA	locational running annual average
LRV	log removal value
m^3	cubic metres
mA	milliamps
MAC	maximum acceptable concentration
MCC	motor control centre

MDD	maximum day demand
MF/UF	microfiltration/ultrafiltration
MFLNO	Ministry of Forest, Lands, and Natural Resource Operations
mg/L	milligrams per litre
MIB	2-methylisoborneol
MIT	membrane integrity testing
MITS	membrane integrity test system
mJ/cm^2	millijoule per centimetre squared
ML/d	megalitres per day
MOH	medical officer of health
MOTI	Ministry of Transportation and Infrastructure
N/R	not required
NBP	Nanoose Bay Peninsula
NDMA	N-nitrosodimethylamine
NEMA	National Electrical Manufacturers Association
NF	nanofiltration
NFPA	National Fire Protection Association
NIPs	network interface panels
NRC	Natural Resources Canada
NTU	nephelometric turbidity unit
OCP	Official Community Plan
OD	outside diameter
OG	operating guideline
PC	personal computer
PDR	predesign report
PDT	pressure decay test
PFD	process flow diagram
PH	peak hour
PLC	programmable logic controller
PST	provincial sales tax
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
QMRA	quantitative microbial risk assessment
R	removal
RDN	Regional District of Nanaimo

RIO	remote I/O
ROW	right-of-way
RTD	resistance temperature detector
RWPS	raw water pump station
SCADA	supervisory control and data acquisition
SCFM	standard cubic feet per minute
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SPD	surge protection device
TBD	to be determined
TCU	true colour unit
TDH	total dynamic head
THMFP	trihalomethane formation potential
TM	technical memorandum
TOC	total organic carbon
TWPS	treated water pump station
UL	Underwriters Laboratories
ULC	Underwriters Laboratories of Canada
UPS	uninterruptible power supply
USEPA	United States Environmental Protection Agency
UV	ultraviolet
UVT	ultraviolet transmittance
VAV	variable air volume
VFD	variable frequency drive
IHA	Island Health Authority
VLAN	virtual local area network
VPN	virtual private network
WC	water closet
WET	waste equalization tank
WTP	water treatment plant
WWTP	wastewater treatment plant

SECTION 1

Introduction

1.1 Background

The Englishman River Water Service (ERWS) provides drinking water to the City of Parksville (CoP) and the Nanoose Bay Peninsula (NBP) in the Regional District of Nanaimo (RDN).

Figure 1-1 shows the location of the existing infrastructure. Water for the CoP system is supplied from 19 wells and an intake in the Englishman River. Treatment is limited to chlorination of the river water. Water for the NBP system is supplied from 12 wells and the CoP system.

Over the past 20 years, considerable effort was devoted to planning the water system so it would both meet community needs and be environmentally sound. Other consultants have monitored water quality, pilot-tested water treatment, and prepared a conceptual design for the project. Pilot testing the aquifer storage recovery (ASR) began in fall 2013 and was completed in April 2014.

With the limited availability of water supply sources in the area, building the Arrowsmith dam in 1999 was the first part of the water supply system development, and a critical element. The dam collects and stores water during winter for release back to the Englishman River in summer for fisheries enhancement and drinking water use.

The next part of the water system development was intended to address the CoP's and RDN's need for additional drinking water, and Island Health's (IH's) requirement for additional water treatment by December 31, 2016. The project scope, costs, and implementation plan were detailed in the Pre-design Report for the Water Intake, Treatment Plant and Supply Mains submitted on June 4, 2014. The report called for a new Englishman River intake structure; river pump station; raw water main; water treatment plant with a capacity of 24 ML/d; and two transmission mains, at a total cost of $32,244,602 (not including engineering during construction or tender costs).

On July 7, 2014, staff from the City of Parksville prepared a Loan Authorization Bylaw Report to Council that reviewed different funding alternatives for the project to determine impacts on water rates and development cost charge rates, including the availability and magnitude of potential provincial and federal funding assistance. This report concluded that due to potential economic impact of the required rate increases on the community, it would not be fiscally responsible to proceed with the entire scope of the project as outlined in the pre-design report without provincial or federal government funding assistance. As an alternative, staff recommended a phased approach to develop the project that better matches the available funding and mitigates the impacts on current rates. This phased approach would address immediate capacity issues for both the CoP and the RDN Nanoose area. Project alternatives with this revised scope were summarized in the memorandum titled "Englishman River Water Service Water Treatment Plant Expansion – Redefining Project Scope and Phasing" from January 16, 2015, with the preferred alternative including 8 ML/d of filtration and 16 ML/d of disinfection.

In August 2015 ERWS received notice of a Federal Government grant for the amount of $6 million for a total project budget of $28.3 million. With this funding in place and through additional analysis, ERWS defined the treatment capacity requirements to include 16 ML/d of filtration and disinfection as part of the Phase 1 of the project, and up to 48 ML/d of treatment in Phase 2. The basis of design of this revised scope is summarized in this document.

1.2 Scope of Work

The original PDR defined for the project to be developed in two phases. Phase 1 would build all the facilities required for 48 ML/d and have equipment to treat 24 ML/d. Treatment equipment up to 48 ML/d would be added in Phase 2.

Based on the revised project budget, the size of the infrastructure built under Phase 1 will meet the required capacity of 16 ML/d with few exceptions. For example, the intake, pump stations, and pipelines (raw water and treated water) will be sized for the ultimate capacity since it is not practical nor economical to phase these. The pump stations, however, will only have equipment for 16 ML/d. Phase 1 will include the intake, raw water pump station, raw water main, 16 ML/d treatment facility, high lift pump station, standby power generator, and transmission mains. Phase 2 will include a new facility that can house up to 32 ML/d of treatment equipment (for a combined total of 48 ML/d), the addition of pumping equipment and related electrical infrastructure to the two pump stations, and expanding the outdoor electrical gear. A summary of major equipment per Phase is presented in Table 1-1.

The revised scope of work for this project including all major civil, mechanical, building mechanical, electrical and structural work is as follows:

1. Intake and raw water pump station
    - Intake structure with fish screens and air scouring system
    - Raw water pumping station building
    - Raw water main
2. Water treatment plant facility
    - Treatment process including sand separators, strainers, coagulation, two stage membrane filtration, UV disinfection, corrosion control and chlorine disinfection.
    - Chemical storage
    - Clearwell and high lift pump station
    - Treated water pumps and pump station
3. Electrical infrastructure
    - New site wide electrical feed and switchgear
    - New site wide standby generator
4. Site works
    - Yard piping
    - Electrical ducts
    - Earthworks
    - Roads
    - Sidewalks
    - Landscaping
    - New parking lots
5. Distribution system
    - Two new transmission mains and connections to the RDN and Springwood reservoirs.

TABLE 1-1
Summary of Major Equipment per Phase

Parameter	Phase 1	Phase 2
Intake structure	Screens and cleaning system for 48 ML/d (capacity limited to 24 ML/d without adding a weir structure)	Add weir structure to increase capacity to 48 ML/d
Low Lift Pumps	2 x 16 ML/d [1 duty, 1 standby]	Add 2 x 16 ML/d in Phase 1 pump station [3 duty, 1 standby]
Sand Separators	3 x 8 ML/d [2 duty, 1 standby]	Add 5 x 16 ML/d in Phase 2 building [6 duty, 1 standby]
Fine Strainers	2 x 16 ML/d [1 duty, 1 standby]	Add 3 x 16 ML/d in Phase 2 building [3 duty, 2 standby]
Membrane trains, 1st stage	Four racks [3 duty, 1 standby] Modules and racks sized for 16 ML/d including minimum 10% spare module capacity	Add five (larger capacity) racks in Phase 2 building [8 duty, 1 standby]
UV disinfection	2 (1 duty, 1 standby), normal configuration 2 duty.	Add 3 reactors in Phase 2 building (3 duty, 2 standby), normal configuration 5 duty.
Chlorine contact tank	1	Add 1 in Phase 2 building with separate chemical addition.
Clearwell	1	Add 320 m^3 clearwell in Phase 2 building
Highlift pump station	2 x 16 ML/d [1 duty, 1 standby]	Add 2 x 16 ML/d in Phase 1 pump station [3 duty, 1 standby]
Membrane trains, 2nd stage	1 rack [1 duty] Modules and rack sized for 16 ML/d including minimum 20% spare module capacity	Add 1 larger rack in Phase 2 building [1 duty, 1 standby]
Second stage feed pumps	2 sized for Phase 1 [1 duty, 1 standby]	Add 2 pumps in Phase 2 building [2 duty, 2 standby]
Backwash Waste (second stage feed tank)	1	Add 1 tank in Phase 2 building
Waste Equalization Tank (to sewer)	1	No change. Use phase 1 equipment
Waste Equalization Pumps	2 [1 duty, 1 standby]	No change. Use phase 1 equipment
Backwash pumps	2 [1 duty, 1 standby]	No change. Use phase 1 equipment
Air scour blowers	2 [1 duty, 1 standby]	No change. Use phase 1 equipment
Compressed Air system	2 [1 duty, 1 standby]	No change. Use phase 1 equipment
CIP/CEB/Neutralization System	2 tanks, each with 2 recirculation pumps [1 duty, 1 standby] and a heat exchange system	No change. Use phase 1 equipment
Chemical Metering and Storage	Bulk storage provided for each chemical Pumps for each chemical [1 duty, 1 standby]	No change in storage capacity No change in membrane chemical pump skids. Continuous chemicals • Add separate CO2 dissolution system

	• Add a separate pump skid for sodium hypochlorite (primary disinfection). • Add a second duty pump or a new head to sodium hydroxide, sodium hypochlorite (secondary disinfection) and coagulant.

MSS = Membrane System Supplier
All flows presented are based on nominal plant capacity; actual design flows (peak) will vary per equipment

The purpose of this predesign report (PDR) is to set out the details of the proposed intake, WTP and watermains, and pump stations. The document includes:

- Review of design flows
- List of regulatory requirements
- Review of water quality and treatment requirements
- Process narrative
- Process testing and design
- Discipline design
- Implementation plan
- Class 4 cost estimate
- Preliminary design drawings

Completion of the PDR will allow the ERWS to move directly to detailed design in November 2015, and on to construction once the project is approved and funded. The intent is for the WTP to be online by January 2018.

1.3 Approach

1.3.1 Project Initiation

The predesign assignment commenced on June 27, 2013, with a project initiation meeting at the RDN office to charter the project team, and to confirm the project scope and schedule. At this meeting, a common understanding of the project goals and objectives was established between the CoP, RDN, and consultant staff. The following project success factors were identified by the project initiation meeting attendees:

- First Nations support of the project
- Department of Fisheries and Oceans approval
- Public acceptance
- Cost effectiveness and affordability
- Low impact and fit with terrain
- Simple operation
- Recognizable sustainability
- Provision of opportunities for public education

Following the project initiation meeting, CoP and RDN staff toured fish hatchery projects in Washington State to view water intake structures similar to those proposed for the ERWS project. They also toured drinking water plants in British Columbia, Manitoba, Ontario, and California to view different water treatment approaches.

At the start of predesign in 2013, the project focused mainly on water supply and intake, and site survey and preliminary geotechnical investigations were completed. For 2014, the work has focused on water treatment, with treatability testing carried out in January and February on various treatment options. The ERWS and CH2M HILL selected the water treatment process at the end of February 2014. Reports and technical memoranda (TM) which were developed during the predesign have been appended to this report.

1.3.2 Public Involvement

The public involvement process mainly involved a series of meetings was held with a community working group (CWG), which consists of 15 community organizations representing the Nanoose First Nation, residents, business, industry, and environmental groups. Public open houses were also held to educate the broader public about the project.

The ERWS established the CWG because it recognized that community engagement is an important part of the project development, and that the CWG would be able to solicit public understanding, input, and support. In four workshops held from December 2013 to April 2014, the CWG's role was to provide early input to the technical team on items of concern, options, and issues to be addressed during design development in advance of broader public engagement.

Based on feedback from the workshops, the CWG's preferences for the intake and raw water pump station were:

- "Honest" architecture, i.e., the pump station function is not disguised by its façade
- Graffiti-proof exterior
- Security features that do not include fencing
- A viewing area for the public to see the intake
- An interpretation area with panels to explain the intake, pump station, and water system

The CWG's preferences for the water treatment plant were:

- A WTP design that would not preclude future addition of nanofiltration (NF)
- Solar panels on roof
- Sending plant waste to a concrete plant, i.e., providing for beneficial re-use of waste
- Use of wood, where practical and affordable

The design team considered these suggestions in developing the predesign.

1.4 References

Vancouver Island Health Authority. 2012. 4-3-2-1-0 Drinking Water Objective. http://www.viha.ca/NR/rdonlyres/F7669DB4-BA69-4EB4-A67A-5EB050AC3857/0/drinkingwaterfactsheetJune2012.pdf.

Health Canada. 2010. *Guidelines for Canadian Drinking Water Quality – Summary Table.* http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/turbidity/index-eng.php.

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SECTION 2

Design Flows

This section describes the existing and projected water demands and WTP capacity, and establishes phasing of the proposed works.

2.1 Water Demand

Table 2-1 summarizes the ERWS's existing water demand and future demand (extrapolated from growth projections). For the design, the projected water demand ("unfactored demand" in the table) was "factored" to allow for uncertainties in future growth and population, changes in water use, and potential climate change and its effect on irrigation. The factored is calculated by multiplying the unfactored demand by a safety factor of 1.25 for City of Parksville demands, and by a factor of 1.15 for Regional District of Nanaimo demands. Table 2-1 shows that by 2050, population will approach 36,000 if growth is high, and factored maximum day demand (MDD) will increase from the current rate of approximately 28 ML/d to 44 ML/d. Details of this analysis are provided in TM 4A – Distribution System Upgrades – Water Demands in Appendix G.

TABLE 2-1
ERWS Water Demand Projections

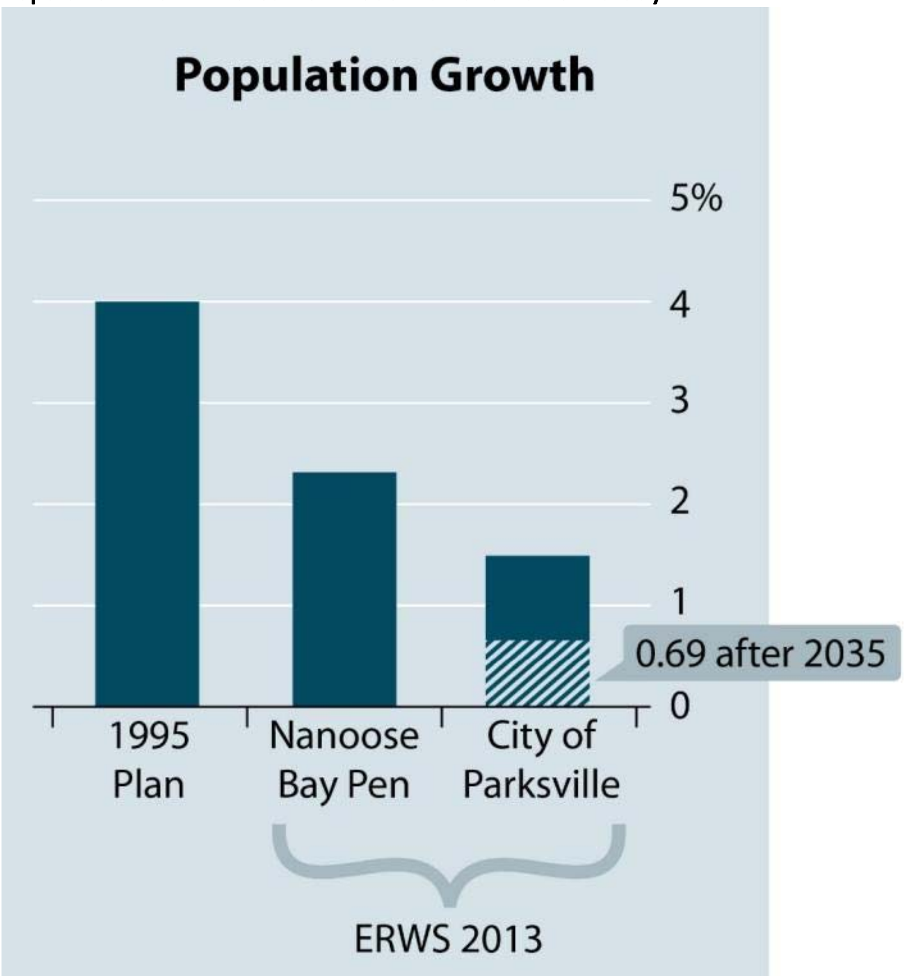
Forecast Year	Population (ca)	Unfactored Demand			Factored Demand		
		BD (ML/d)	ADD (ML/d)	MDD (ML/d)	BD (ML/d)	ADD (ML/d)	MDD (ML/d)
2013 (existing)	17,550	4.5	8.8	22.9	5.5	10.8	28.0
2018	19,033	4.9	9.3	24.1	5.9	11.4	29.4
2035	24,290	6.1	11.2	27.8	7.4	13.7	33.9
2050	29,348	7.3	12.9	31.3	8.9	15.7	38.1
2050 (high growth scenario)	35,818	9.0	15.3	36.2	11.0	18.7	44.2

Notes:
"Factored demand" means projected water demands multiplied by a factor of safety. "Unfactored demand" means projected water demands without the factor of safety.
ADD = average daily demand
BD = base demand
MDD = maximum day demand

Residential base demands (primarily indoor water usage) were calculated to be approximately 160 litres per capita per day (L/ca/day) for both Parksville and the NBP, which is consistent with benchmarks for single family homes retrofitted with water-efficient fixtures. The seasonal demand (primarily irrigation) was calculated from maximum day demands in 2009, which was the highest recorded demand year for Parksville (and many other water systems in southwest BC) in recent history. An irrigation rate of 34,300 litres per hectare per day (L/ha/day) was calculated using the 2009 MDD data. Irrigated areas for single family residential lots were calculated as 65% of lot area in Parksville and 45% of lot area in NBP, capping out at 0.3 hectares (ha). Relatively smaller irrigated areas were used for multi-family and institutional, commercial, and industrial (ICI) lots.

Water demands predicted in this study are lower than those predicted in previous studies. The water demand projections for this study for the CoP are based on a yearly increase in population of 1.53%, decreasing gradually over time to 0.69% per year by 2035. For the high-growth scenario, the estimated population growth is 1.8% per year. For the NBP, population growth is estimated at 2.2% per year. These numbers compare to an annual growth rate of 4.0% used in the 1995 *KRC Consultants Master Plan for a Regional Supply System*. Figure 2-1 shows the population growth rates from the plan and the current study.

FIGURE 2-1
Population Growth Rates from 1995 Plan and Current Study



The factored average day demand predicted in this study ranges from 615 L/ca/day to 522 L/ca/day as the region densifies and per capita irrigated areas drop. An average day demand of 550 L/ca/day was used in the 1995 KRC study. The factored MDD unit rates used in this study range from 1,595 L/ca/day to 1,234 L/ca/day as the service area densifies. A MMD unit rate of 1,375 L/ca/day was used in the 1995 KRC study. The lower population projections combined with comparable demand unit rates have resulted in lower predicted demands.

ICI demands were not explicitly accounted for in the 1995 KRC study, but are accounted for in the current study. The current study unit rates quoted above are based on residential population but include ICI demands.

2.2 Water Treatment Plant Capacity

The existing CoP and Nanoose wells have a total estimated capacity of 11.8 ML/d. Table 2-2 shows the required WTP capacity considering factored demands, assuming the well capacity can be maintained to 2050.

TABLE 2-2
Required Water Treatment Plant Capacity

Forecast Year	Factored MDD (ML/d)	Ground Water Well Capacity (ML/d)	Required Firm Treatment Plant Capacity (ML/d)
2013 (existing)	28.0	9.5	18.5
2018	29.5	9.5	20.0
2035	33.9	9.5	24.4
2050	38.1	9.5	28.6
2050 (high growth scenario)	44.2	9.5	34.7

Notes:
ASR = aquifer storage recovery
MDD = maximum day demand
Firm capacity = capacity with largest unit out of service

2.3 Phasing

Based on the new phasing approach and budgetary constraints, the initial capacity of the phased WTP would be 16 ML/d (Phase 1 built in 2016) based on un-factored demands. This assumes that the groundwater well system can supply 11.8 ML/d during peak demand periods and the initial WTP capacity meets regional demand until 2026. To mitigate the risk of using these assumptions, the Phase 2 expansion would occur in 2024 to meet the 24 ML/d factored demand by 2026. Table 2-3 shows the proposed sizing and phasing of the intake, pump station, and WTP. Please note that the intake screen and raw water supply mains are provided for the ultimate capacity of 48 ML/d as it is not practical nor cost-efficient to build these in multiple phases.

TABLE 2-3
Proposed Sizing and Phasing of Infrastructure

Infrastructure	Nominal Capacity	
	Phase 1, 2018	Phase 2, 2024 and beyond
Intake Screen	48 (limited to 24 until weir is built)	48 (once weir is built)
Raw Water Pump Station	16	24-48
Raw Water Supply Main to WTP	48	48
WTP	16	24-48

Notes:
1. Nominal Capacity is based on flows over 24 hours

Table 2-3 shows that the project infrastructure will be built in two phases: the Phase 1, which is expected to meet the community's water demands until 2024; and Phase 2, which is expected to meet the water demands until 2050. This phasing strategy is intended to meet community needs affordably and to make construction practical.

SECTION 3

Regulatory Requirements

This section identifies the regulatory requirements related to the volume of water that can be withdrawn from the Englishman River and the treated water quality.

3.1 Water License

The Ministry of Forest, Lands, and Natural Resource Operations (MFLNO) has approved the proposed point of diversion and the withdrawal of water from the Englishman River through a conditional water license (C129170) issued on January 17, 2013. The license allows for withdrawal of up to 48 ML/d, which is the ultimate capacity of the new intake and water supply system.

3.2 Island Health Authority

The IHA issues construction permits and operating permits under the Drinking Water Protection Act. The IHA has stipulated that the ERWS must complete a new WTP by December 2016.

3.3 Water Quality Regulations

3.3.1 Guidelines for Canadian Drinking Water Quality

The primary consideration for drinking water supply is the protection of public health. Specifically, water supplied to customers should be safe, palatable, and aesthetically pleasing. It must be free of pathogenic (disease-causing) organisms and hazardous chemicals, and it should be free of colour, unpleasant taste, and odour.

Water quality is primarily evaluated using *Guidelines for Canadian Drinking Water Quality* (GCDWQ), which specifies maximum acceptable concentrations (MACs) for microbiological, chemical, and physical parameters for drinking water provided by a waterworks system. It also includes aesthetic objectives (AOs) for non-health-related parameters that contribute to how the water looks, smells, and tastes; this is important because if the water is unappealing, customers may use alternative, potentially unsafe, sources.

Traditionally, microbiological characteristics have been viewed as the most important drinking water concern because of their association with water-borne diseases. Chemical contaminants are a concern because of possible short- or long-term health effects. Physical characteristics, such as turbidity, pH, colour, taste, and odour affect the aesthetics of the water, and are most evident to customers.

The GCDWQ sets limits for approximately 90 water quality parameters. In practice, a system's water quality and treatment requirements are typically assessed using about 11 water quality parameters (alkalinity, arsenic, calcium, colour, iron, manganese, pH, sodium, total organic carbon, trihalomethanes, and turbidity).

3.3.2 Other Requirements

Other treatment requirements and performance objectives include:

- Provincial guidelines and directives of the BC Drinking Water Protection Act, the BC Drinking Water Protection Regulation, and IHA's "4-3-2-1-0 Dual Treatment Guidelines"
- Regulations and regulatory drivers from other jurisdictions, including the United States Environmental Protection Agency (USEPA), reviewed in the context of the ERWS

In addition, general industry trends and knowledge of regulatory history in other jurisdictions were considered in developing the proposed treatment objectives for the ERWS WTP, including:

- Maintaining particulate removal, with performance objectives based on individual filter performance

- Managing organics present in the source water to provide control of disinfection byproducts (regulated and unregulated) as well as to promote water stability as the drinking water is conveyed across the system

The CWG's preference that drinking water be provided in a sustainable manner was also considered. Sustainable practices potentially applicable to this project include minimizing the addition of treatment chemicals to the drinking water, managing residuals (waste produced by the treatment process), reusing wastewater, and recovering heat from pumping.

SECTION 4

Water Quality and Treatment Requirements

This section sets out the water quality and treatment requirements and the performance objectives for the proposed ERWS WTP.

4.1 Raw Water Quality

Over the past several years, the ERWS has tested the source water for a range of physical and microbiological parameters, organics, anions, cations, metals, and disinfection byproduct formation potential.

Table 4-1 summarizes the raw water quality used to design the WTP.

TABLE 4-1
Primary Water Quality Characteristics for the Englishman River (September 2011 to August 2012)

	GCDWQ		**Englishman River**	
	AO or OG	**MAC**	**Approximate Range or Median Value**	**Number of Tests**
Alkalinity, mg/L $CaCO_3$	N/A	N/A	9–24	15
Hardness, mg/L $CaCO_3$	≤ 200		13–30	15
Turbidity,[a] NTU	≤ 0.1/0.1/1.0/0.3		< 1–104	207
Colour, TCU	≤ 15		< 5–77	210
Temperature, °C	≤ 15			
pH	6.5–8.5		6.58–7.91	209
TOC, mg/L	N/A	N/A	0.7–6.7	24
HAAFP, mg/L	N/A	N/A	0.048	2
THMFP, mg/L			0.330	3
% UV transmittance	N/A	N/A	69.8–98.9	23
Aluminum (total),[b] mg/L	0.1/0.2		0.014–1.510	15
Arsenic (total), mg/L		0.010	< 0.0001–0.0009	15
Calcium (total), mg/L			4.28–11.00	13
Iron (total), mg/L	≤ 0.3		0.048–2.64	15
Manganese, mg/L	≤ 0.05		0.002–0.069	15
Total coliform,[c] cfu/100 mL		Non-detect	110–1100	13
E. coli,[c] cfu/100 mL		Non-detect	1–100	13

Source: Associated Engineering, Technical Memorandum (TM) WQ1

Notes:
[a]Refer to the turbidity section of GCDWQ; turbidity guideline is under review by Health Canada
[b]This is an operational guidance value, applying only to drinking water treatment plants using aluminum-based coagulants, 0.1 mg/L is for conventional treatment plants, and 0.2 mg/L is for other types of treatment systems.
[c]Refer to Table 1 of GCDWQ.

°C = degrees Celsius
AO = aesthetic objective
$CaCO_3$ = calcium carbonate
cfu = colony-forming unit
GCDWQ = *Guidelines for Canadian Drinking Water Quality*
HAAFP = haloacetic acid formation potential
MAC = maximum acceptable concentration
mg/L = milligrams per litre
NTU = nephelometric turbidity unit
OG = operating guideline
TCU = true colour unit
THMFP = trihalomethane formation potential
TOC = total organic carbon
UV = ultraviolet

The data indicate the Englishman River is a neutral-pH, low-alkalinity, and calcium-deficient water source. Colour levels are moderate, and turbidity is relatively low most of the time, with sudden, short-duration, rain-induced turbidity events that increase turbidity levels to around 100 NTU. The neutral pH and low alkalinity and calcium levels indicate the water will be moderately corrosive to copper, lead, and uncoated steel pipe in plumbing.

4.2 Treatment Requirements and Performance Objectives

Table 4-2 summarizes the proposed water quality and treatment requirements for the ERWS WTP, along with the related performance objectives necessary to achieve the treatment values in the regulations identified in Section 3.3.

TABLE 4-2
Proposed Water Quality and Treatment Requirements and Performance Objectives for the ERWS WTP

Parameter	Applicable Regulation or Guideline	Treatment Requirements	Performance Objective	Comment
Pathogen Removal				
Giardia	"4-3-2-1-0 Dual Treatment Guidelines" (supplemented by *Proposed Guideline for Enteric Protozoa: Giardia and Cryptosporidium*, Health Canada, 2010)	3.0-log reduction	See performance objective for *Cryptosporidium*	Provide at least 0.5-log reduction by inactivation
Cryptosporidium		3.0-log reduction	Achieve ≤ 0.15 NTU in individual filter effluent, in ≥ 95 % of monthly samples (based on continuous sampling)[a]	Provide by removal only, based on achieving 0.3 NTU in combined filter effluent, in 95% of monthly samples, to earn pathogen removal credits
Viruses	"4-3-2-1-0 Dual Treatment Guidelines"	4.0-log reduction	See performance objective for *Cryptosporidium*	Provide at least 2.0-log reduction by inactivation
Bacteria	BC Drinking Water Protection Regulation	Fecal coliform non-detect *E. Coli* non-detect Total coliform non-detect in 90% of monthly samples, and all samples ≤ 10 cfu/100 mL	Maintain a chlorine residual ≥ 0.25 mg/L across the distribution system	Match choice of disinfectant used for residual maintenance across the ERWS system
Disinfection By-Products				
THMs	USEPA Stage 2 disinfectants and disinfection by-products rule	≤ 80 µg/L	Reduce as low as possible	Based on an LRAA
HAAs		≤ 60 µg/L	Reduce as low as possible	Based on an LRAA
Corrosion control	USEPA lead and copper rule		Maintain alkalinity ≥ 35 mg/L and pH 9 ± 0.2	Match treatment across the CoP system

TABLE 4-2
Proposed Water Quality and Treatment Requirements and Performance Objectives for the ERWS WTP

Parameter	Applicable Regulation or Guideline	Treatment Requirements	Performance Objective	Comment
Turbidity	"4-3-2-1-0 Dual Treatment Guidelines"	≤ 1.0 NTU in plant effluent ≤ 5.0 NTU in the distribution system	Performance objectives for turbidity to earn pathogen removal credits are for filter effluent	
Aesthetics				
Colour	GCDWQ	≤ 15 TCU	≤ 5 TCU	

Notes:
[a] All other parameters in accordance with GCDWQ.

cfu = colony-forming unit
GCDWQ = *Guidelines for Canadian Drinking Water Quality*
HAA = haloacetic acid
LRAA = locational running annual average
MIB = 2-methylisoborneol
NDMA = N-nitrosodimethylamine
NTU = nephelometric turbidity unit
OG = operating guideline
TCU = true colour unit
THM = trihalomethane
USEPA = U.S. Environmental Protection Agency

4.3 Treatment Process Options

In October 2013, CH2M HILL presented the following treatment options to the ERWS:

- 1A – Enhanced coagulation, two-stage polymeric membrane filtration
- 1B – Enhanced coagulation, ceramic ultrafiltration
- 2 – Polymeric membrane filtration, nanofiltration
- 3 – Polymeric membrane filtration, ion exchange
- 4 – Polymeric membrane filtration, ozone, and biologically active carbon contactors

After reviewing the design criteria and concept layouts, the ERWS indicated it preferred either Option 1A or Option 2.

4.3.1 Option 1A

In Option 1A, raw water from the raw water pump station (RWPS) would be pre-treated through sand separators and 300-µm strainers. Coagulant would be added upstream of the strainers. From the strainers, water would be filtered through primary-stage polymeric microfiltration/ultrafiltration (MF/UF) membranes.

Spent backwash water from the MF/UF membrane would be pumped through a secondary-stage membrane. Permeate from the two membrane stages would be blended upstream of the ultraviolet (UV) reactor. Waste flow from the secondary-stage membrane would be discharged to the sanitary sewer.

Permeate from both membranes would be disinfected by UV and chlorine prior to pH and alkalinity adjustment.

4.3.2 Option 2

In Option 2, raw water from the RWPS would be pre-treated through a sand separator and 300-µm strainers. Since the backwash water from the sand separator and the strainers would be free of chemicals, it could be discharged to an enhanced wetland. From the strainers, pre-treated water would be filtered through the MF/UF membranes. Permeate from the MF/UF membranes would be NF-membrane-filtered in a 3-stage system.

Spent backwash water from the MF/UF and concentrate from the NF would be sent to the enhanced wetland. The NF permeate would be disinfected by UV and chlorine prior to pH and alkalinity adjustment. Chemical waste from the membrane cleaning systems would be pumped to the sanitary sewer.

4.3.3 Treatability Testing and Cost Estimates

Treatability testing was conducted and cost estimating was done to evaluate the two treatment options.

The treatability testing was performed on a raw water sample with high colour and turbidity from the Englishman River at the preferred intake location after a large rainfall event on January 11, 2014. The purpose was to test the effectiveness of each option and establish design information for the subsequent cost estimating. The options proved equally effective in meeting the design objectives.

Following the treatability testing, parametric cost estimates were prepared to determine the capital and operating and maintenance costs.

4.4 Recommended Treatment Option

In February 2014, CH2M HILL held a workshop with the ERWS to present a comparison of the preferred treatment options. The main advantage of Option 2 is that it would not use chemicals in the treatment process (excluding disinfection), which would eliminate waste flow to the wastewater treatment plant and would be preferable to the public. However, the NF membranes, which are critical to the chemical-free treatment process, have significantly higher capital and operational (energy) costs, with the 20-year lifecycle costs approximately $17 million more than Option 1A. These costs exceed the project budget, so Option 1A was chosen as the preferred option.

SECTION 5

Process Narrative

This section describes the proposed operation and control philosophy for the components of the new water system. The design criteria for each component are given in Section 6.

5.1 Overview

This project consists of the following components:

- Intake and raw water pump station
- Water treatment plant
- Distribution system upgrades

The WTP consists of several unit processes, described in subsections below. The main parameter affecting unit process operation is the production rate, which is the net rate of finished water flow into the distribution system. The plant operator sets the desired production rate based on the system demand, available water from other sources (e.g., the groundwater wells), and the system reservoir levels. The primary objective in setting the production rate is to avoid the multiple start-stops of the treatment train that occur when production rate is significantly higher than system demand. The WTP will be designed for a minimum flow rate of 8 ML/d which would require running the plant for 12 hours to meet the projected minimum water demand of 4 ML/d during the winter.

If reservoir levels fall to below minimum setpoints (because of fireflow or other uses), the SCADA system will transmit an alarm condition to the operator, who will increase the plant production setpoint to compensate. The following automated SCADA sequence will then occur:

- High Lift (finished water) pumps will start and ramp up to a specified setpoint flow
- As the high lift pumps draw down the clearwell to a set level (proportional to flow rate), the raw water pumping rate will increase to the setpoint rate (plus an allowance for process waste)
- The raw water pumping rate will adjust as necessary to maintain the clearwell level within a prescribed band
- Coagulant will be added to the feed water in the raw water main (to allow adequate contact time) at the selected dosage and according to the flow measured by the raw water flow meter
- Chlorine will be added downstream of the UV units at the disinfectant dosage and according to the flow measured by the UV flow meter
- Sodium hydroxide and carbon dioxide for corrosion control will be added downstream of the chlorine contact tank according to the flow measured by the UV flow meter

Operation and control of the unit processes are described in the remainder of this section.

5.2 Intake and Raw Water Pump Station

The intake and raw water pump station (RWPS) consist of three main components:

- Obermeyer weir (Phase 2)
- Intake structure
- Raw water pumps

5.2.1 Obermeyer Weir

The minimum water depth at the intake site is too low (approximately 0.45 m) to extract the ultimate design flow from the river; therefore, a weir is needed to raise the water depth as part of the Phase 2 scope. The weir will consist of a pneumatic crest gate connected to a concrete sill that will lie across the river. The sill will extend from the north side of the riverbank to a large rock on the south bank. A fish ladder will be carved out of the rock so fish can pass around the weir.

The weir will be hinged and will normally lie flat and flush with the bed of the river. The operator will be able to raise or lower the weir by pressurizing or deflating an air bag beneath it. Pressurized air will be provided by an air compressor and receiver in the RWPS. The need to raise the weir will depend on the natural water level in the river, the flow required by the WTP, and the head loss that occurs through the fish screens. Generally, this condition will occur in the summer, when demand is high (greater than 24 ML/d) and river levels are low. The weir will be controlled manually (the SCADA system will not adjust it automatically) since only intermittent adjustment will be needed.

5.2.2 Intake Structure

The intake will consist of a sloped concrete structure with fish screens. The structure will be divided into two bays so one can be taken out of service for maintenance. The intake screens will be designed to protect fish and other aquatic life at the intake, and to keep debris from entering the raw water supply. There will be four screen panels (two for each bay).

The fish screens will be cleaned by an automated air backwash system consisting of air piping at the intake and a compressor/receiver unit in the RWPS. There will be one air header per fish screen; each air header will have a dedicated air line, with the control valves located inside the RWPS.

The frequency of screen cleaning will depend on the amount of debris that accumulates on the screens. Once the cleaning interval has been established, it is anticipated that cleaning will occur at night to avoid interference with recreational activities along the river. Screen cleaning will be sequenced, starting with the upstream screen and progressing downstream so that adjacent screens do not catch dislodged debris.

During high debris periods (e.g. spring runoff), the operator can increase the cleaning frequency as needed. The operator will also be able to initiate screen cleaning manually from the RWPS for demonstration purposes.

5.2.3 Raw Water Pump Station

The raw water pumps will be sized to provide pressure to treat the water through the entire treatment process (sand separators, fine strainers, the primary-stage membrane system, UV disinfection, CCT, and corrosion control), and will discharge into the clearwell at the WTP. The pumps will be controlled by the water level in the clearwell; however, they will also be interlocked with the river water level inside the intake structure (as indicated by level transmitters inside each intake bay). As the production rate increases, a corresponding increase in the river water level will be needed to submerge the pumps adequately. If the river water level is too low, the SCADA system will limit the pumping rate. Initial hydraulics indicate the minimum water level in the river is adequate for the required Phase 1 peak raw water flow rate of 21.6 ML/d. The raw water pumps are provided and controlled by the membrane system supplier (MSS).

The RWPS will house two 21.6-ML/d pumps. All pumps will be vertical turbine in cans with variable frequency drives (VFDs). Phase 2 will have four 21.6 ML/d pumps. During Phase 1, the VFDs will allow the pumps to be turned down to approximately 8 ML/d to match the minimum flow of the WTP. The SCADA system will be programmed to select the pumps required to meet the production rate. The operator will be able to select pump priority and to designate pumps that should be taken out of service through the SCADA system as needed.

Isolation and air/vacuum valves will be provided on pump discharges. Operation of the isolation valves will be controlled manually. A hydropneumatic tank for surge suppression during power failures will be provided; this tank will be hydraulically operated and will not require a control system.

5.3 Feedwater Coagulation Addition

A high-basicity polyaluminum chloride coagulant will be added to the feed water in the raw water main to allow for sufficient contact time prior to membrane filtration (5-10 minutes of contact time). A proof pilot test program will be completed in the winter of 2015/2016 (December to April) to determine the optimal contact time and whether and increasing the pH to 7.5 by adding caustic soda would improve color removal and membrane performance while reducing coagulant dosages. In combination with the membrane filtration system, the coagulant will remove color and dissolved organic carbon. Operators will adjust the coagulant dose setpoint manually, but automatic adjustment will also be possible via SCADA based on flow changes measured in the raw water magnetic flow meters. We are also investigating the option to measure changes of color post filtration via a surrogate (transmittance) to adjust the coagulant dose in response to changes in color. The coagulant will be stored in tanks in the chemical storage area and added to the feed water instream using peristaltic chemical feed pumps. Due to the low velocities in the raw water main, particularly during Phase 1, carrier dilution water will be used to convey and increase mixing of both caustic (if used) and coagulant.

5.4 Sand Separators and Fine Strainers

Raw water will be pumped to the WTP through a raw water main, which will enter at the south west corner of the site. The first unit process at the WTP will be pre-treatment, which consists of vortex sand separators and fine strainers. The pre-treatment system is designed to remove larger particulates from storm events (using the sand separators), reduce the solids loading, and protect the membrane filters (using the fine screens). The sand separators will normally be by-passed, and will be used only during high turbidity and storm events.

The sand separators can be purged regularly using a timer. Underflows from the sand separators will be discharged to the WET. Pressure differential transmitters in the strainers will automatically trigger a backwash using an external source of water. Spent backwash water from the strainers will be equalized in the waste equalization tank (WET) and pumped to the sanitary sewer.

The intake and raw water main are designed for 48 ML/d and therefore during Phase 1 it is expected that the low velocities through these structures will induce sand to settle. The plant will be operated at design capacity for 120 minutes once a week to re-suspend the sand and induce removal through the sand separators.

5.5 Ultrafiltration System

The membrane filtration unit process will use ultrafiltration (UF) technology from H2O Innovation, the membrane system supplier (MSS). Components that will be supplied under the equipment pre-purchase contract with the MSS include the list below. For a detailed scope of equipment supply and vendor P&IDs, see Appendix O.

- UF feed pumps (described in Section 5.2.3)
- Sand separators and fine screens
- Membrane filters
- Backwash and air scour system
- Chemical-enhanced backwash (CEB) and clean-in-place (CIP) system
- All chemical metering systems, except for CO2
- All instrumentation, controls, and SCADA related to the above.

5.5.1 Feed Pumps

As described in Section 5.2.3, the raw water pumps at the RWPS will pressurize the feedwater for the UF modules. During the membrane cleaning cycles (backwash, air scour, and CEB/CIP), the raw water pumps will not pump to the UF system.

5.5.2 Membranes and Membrane Assembly

The membrane filters will be arranged in two stages to increase the recovery of the UF system.

Pre-treated water will be pumped into the primary-stage membrane filters. Permeate from both membrane stages will be blended prior to UV disinfection. The primary stage of the UF system will recover approximately 96 percent of the feed water as permeate (i.e., will achieve 96 percent recovery). The remaining 4% percent of the water will be spent backwash water, which will be directed into a UF backwash break tank. A secondary-stage UF system will convert 75 percent of the primary-stage backwash into permeate, bringing the overall recovery of the membrane system to greater than 99 percent. Spent backwash water from the secondary-stage membrane will be equalized in the WET and pumped to the sanitary sewer. The 2nd stage membrane waste flow will be the largest flow stream going to the WET and therefore it will be operated with the intent to limit the flow from the WET to the sewer to less than 10 L/s. This is projected to be required only in the months of May to September based on current demand projections and a design capacity of 16 ML/d.

Both membrane stages will filter water in the same manner. During a filtration cycle, the membrane trains will filter feed water through polymeric hollow fibers. The membrane filters will operate in dead-end filtration mode and therefore will not generate waste, while the membrane train is filtering water. Over time, foulants (dissolved and suspended constituents) will accumulate in the membrane and decrease membrane productivity (also known as permeability [flow per unit of applied pressure]). A three-tier process consisting of backwashes with air scour, chemically enhanced backwashes (CEB), and clean-in-place (CIP) will be used to restore membrane permeability. These three activities will occur when the membrane train is not in filtration mode. Membranes will be backwashed and air-scoured to remove suspended solids every 45 to 60 minutes. Once a day (at design capacity of 16 ML/d), a CEB (6 chlorinated and 1 acid CEB per week) will remove additional organic and biological foulants. Approximately once every 45 days, a chlorine followed by an acid CIP will be performed to remove dissolved constituents and organics, respectively. These CIPs will be performed with heated water (target 40 °C).

A plant demand setpoint will be used to set the permeate flow rate through the MFS. The control system will automatically select the number of trains required to meet production capacity. During filtration, individual membrane trains will operate at a flow setpoint set automatically by the MFS control system. Trains will go offline frequently for backwash, CEB, CIP, or MIT, which could normally produce large variability in membrane permeate and feed flows of up to 20% as discussed in Section 6.1.1.

5.5.3 Membrane Integrity Test System

The membrane filtration system will include a two-tier membrane integrity test (MIT) system that is compliant with IHA and US Environmental Protection Agency's Long Term 2 Extended Surface Water Treatment Rule (LT2ESTWR). The MIT system will include an indirect test in the form of laser turbidimeters on the permeate of each train. A direct integrity test will be provided in the form of a pressure decay test (PDT), which will calculate a log removal value (LRV) for the membrane filtration system.

The direct integrity test system procedure will be automatic, and will include:

- Placing the train offline
- Purging all the water from inside the membrane modules, cassettes and piping with air
- Pressurizing the membranes to a predetermined pressure (start of the test)
- Observing the pressure decay for 5 minutes

- Recording the last pressure (end of test)
- Re-priming the membrane using a vent valve and the ejector system.

A compressed air system will supply air for both the MIT system and the pneumatic valve actuators in the membrane filtration system.

5.5.4 Backwash System

During the filtration cycle, the membrane train will filter pre-treated water continuously (without a waste stream) until a filter run volume or recovery set point is reached, typically after 30 to 45 minutes. At the end of the filtration cycle, the train will be taken off line, backwashed with permeate, and air scoured to remove accumulated solids. Permeate for backwash will be pumped from the first cell of the CCT. A second step called a forward flush may also be completed to further rinse the membranes. This step would require the feed pumps to operate at approximately 110 percent of nominal flow rates. Spent backwash and flush water will be drained by gravity to the UF membrane backwash break tank (primary-stage membrane backwash) or the WET (secondary-stage membrane backwash). Once the drain is complete, the train will be ready to resume filtration. Backwashes will be triggered automatically by the membrane control system, or manually initiated if required.

5.5.5 CEB/CIP System

5.5.5.1 CEB System

Chemically enhanced backwashes (CEBs) will be performed every day (6 days per week with chlorine and one day per week with acid) when the plant is operating at the design capacity of 16 ML/d. Each CEB will continue for 30 minutes per train. The procedure will consist of running the permeate backwards through the filters, followed by recirculating a cleaning solution through the membranes. The cleaning solution will consist of membrane permeate and 100 mg/L sodium hypochlorite (for a chlorine CEB) or 500 mg/L sulfuric acid (for an acid CEB). Heating the cleaning solution will be optional. The operator will initiate CEBs manually. Two indicators will be provided on the SCADA system to facilitate tracking (1) CEB progress, (2) permeate produced since last CEB, and (3) time since last CEB.

The CEB will include transferring permeate from the CEB/CIP/neutralization tank to the membrane train using the recirculation pumps. Chemicals will be added during the transfer. Once the cleaning solution is in the membrane tank, the recirculation pumps will recirculate the CEB solution for a predetermined amount of time. The pH and chlorine residual (only if below 200 mg/L) will be monitored during the recirculation step. Once the CEB is completed, the recirculation pump will transfer the solution out and flush the membrane train with permeate and raw water. The chlorine residual and the pH of the flush water will be monitored to ensure that the membrane train is within specifications. Both spent cleaning solution and flush water will be transferred to the neutralization tank. Neutralization chemicals will be added during the transfer step.

5.5.5.2 CIP System

A CIP will be conducted on each train once every 45 days. During chlorine CIP, a 1,000-mg/L sodium hypochlorite solution will be recirculated through the membranes. At the end of the CIP, the train will be flushed with permeate and raw water. The CIP will then be repeated with 2,000 mg/L citric acid, with sulfuric acid to achieve a target pH of 2. The heating temperature of the CIP water will be targeted at 40°C. The train will also be flushed at the end of the acid CIP. Each CIP will take approximately 4 – 5 hours. The effectiveness of the CIP might be enhanced by using sodium hydroxide to increase the pH of the chlorine CIP to above 10.5.

The operator will be able to initiate CIPs manually. The SCADA system will have two indicators to facilitate operator tracking of (1) CIPs, (2) permeate produced since last CIP, and (3) time since last CIP. The CIP sequence will be identical to the CEB sequence, except only pH (not chlorine concentration) will be monitored during the recirculation step, because the chlorine concentration will be higher than the high end of the analyzer's range.

5.5.5.3 Neutralization System

Spent chemical solution and flush water will be de-chlorinated and pH-adjusted in a CEB/CIP/neutralization tanks. The neutralization sequence will be fully automated. Sodium hydroxide and sodium bisulphite will be added to neutralize chlorine cleans, and sodium hydroxide will be used to neutralize acid cleans. The chemicals will be added in-line during the transfer first. When the transfer is complete, the partially neutralized solution will be recirculated for 5 to 10 minutes while more chemicals are added and pH and chlorine are monitored online. The neutralization will be complete once the chlorine residual is less than 0.1 mg/L and pH is 7 ± 0.2. After neutralization, the operator will manually initiate transfer of spent chemical solutions to the WET for disposal.

5.6 Disinfection

Disinfection of the blended permeate stream will use two inactivation processes: ultraviolet (UV) light irradiation and chlorination.

5.6.1 UV Disinfection

A UV disinfection system will be provided for primary inactivation of *Cryptosporidium* and *Giardia*. Two in-line medium-pressure UV units are proposed, each with an upstream magnetic flow meter and a motorized isolation valve according to regulatory requirements. The UV units will have a warm-up time; that is, they will be energized for a few minutes before the membrane feed pumps start operation. Normally one UV unit will handle full plant flow; the operator can select which unit to use in order to cycle the units. The UV control system will monitor the UV transmittance of the water and adjust the dosage to obtain the target inactivation. The overall SCADA system will monitor log inactivation values for UV and chlorine. If a UV unit fails, the SCADA system may shut down plant production until the standby UV unit is energized if (as will be likely during high flows) the *Giardia* inactivation target cannot be met using the CCT. Otherwise, if the CCT can provide adequate *Giardia* and virus inactivation (as it likely will be able to do during low flows), the plant will continue to operate.

Each UV reactor will be monitored to determine whether it operates within validated conditions. Off-specification operation will occur when the UV reactor operates outside of its validated limits for flow and UVT. Flows greater than the validated maximum flow or UVT less than the validated minimum UVT will result in off-spec water. UV dose monitoring parameters (e.g., flow rate, UV intensity, UVT, number of lamps on, etc.) will be monitored every five minutes and recorded every four hours per UV Disinfection Guidance Manual recommendations. Off-specification alarms will be recorded at five-minute intervals. These records will be used to determine the percentage of monthly flow volume that is off-specification. It is anticipated that interruptions to the UV system will be infrequent and compliant with the maximum five percent off-spec water per month requirement. Compliance with this requirement will be monitored and adjustments to plant operations will be made, if necessary.

5.6.2 Chlorination

Chlorine will be used for chemical inactivation of pathogens; this step will occur in the CCT. Water from the UV system will enter the first cell (backwash storage). The water will be chlorinated (using the UV unit flow signal) as it overflows into the second cell of the CCT. The CCT will be baffled, and an exit weir will maintain the CCT in a full state to provide adequate disinfection time. Chlorine concentration will be measured at the end of the CCT to confirm adequate disinfection. The CCT will be sized for 4-log virus inactivation, but will also be able to provide 0.5-log *Giardia* inactivation at lower flows. Measurement of pH will indicate whether further pH adjustment will be required for corrosion control.

5.7 Corrosion Control

Sodium hydroxide and carbon dioxide will be added for corrosion control in the distribution system (pH and alkalinity adjustment). The carbon dioxide will be added at the beginning of the CCT and the sodium hydroxide will be added as the water passes over the weir of the CCT into the clearwell. Additional chlorine could also be added to increase residual for the distribution system. Chlorine and pH will be re-measured in the finished water pipe downstream of the station to confirm that the desired water quality has been achieved. The dosing for all these chemicals will be determined according to flow measured by the UV flow meters.

The finished water will be directed to the clearwell, which is a storage tank that will balance flow differences between production rate and high lift pumping rate.

5.8 High Lift Pump Station

The HLPS will house two 21.6-ML/d pumps. Pumps will be vertical turbine with VFDs. Phase 2 will have four 21.6 ML/d pumps. The discharge of each high lift pump will have a magnetic flow meter, which will provide a flow signal for production purposes and allow for maintenance of the pumping rate regardless of system pressure changes. The HLPS will be designed to feed a single pressure zone with two pipelines: W1, which will send water to the Regional District of Nanaimo; and W2, which will send water to the Springwood reservoir in Parksville. The pumps will be controlled based on a pre-set level band in the reservoirs. The operator will be able to select the priority order of pumps through SCADA, as well as to establish production rates and lock pumps out for maintenance. A hydro-pneumatic tank for surge suppression during power failures will be provided; this tank will be hydraulically operated and will not require a control system.

5.9 Ancillary Systems

5.9.1 Waste Equalization Tank (WET)

All process wastes (membrane, floor drains, and analyzers) will be equalized in the WET. A level-sensor will be provided in the storage tank and will be monitored by the SCADA system. Two submersible pumps with a common magnetic flow meters will be used to pump the waste to the sanitary sewer at a flow not to exceed 10 L/s which is the assigned limit for the WTP. The tank will be designed to allow for sand to settle, be stored and vacuum educted without impacting pump operation. Sanitary flows from washrooms, lab and the janitor room will be collected and directed to the sewer separately.

5.9.2 Chemical Containment

A chemical spill collection tank will be provided to collect minor spills and washdown flows from chemical deliveries and washdowns. A level-sensor will be provided to detect any spills in the collection tank.

SECTION 6
Process Design

This section contains design criteria for the ERWS WTP. These design criteria will be a basis for the facility design. The unit processes covered include:

- Raw water pump station
- Sand separators and pre-strainers
- UF membrane filtration system
- UV disinfection
- Post-treatment for water stabilization and pH adjustment
- High Lift pump station
- Residuals management

6.1 Overview

6.1.1 Flow Considerations

The production capacity for Phase 1 of the WTP will be 16 ML/d. In Phase 2, the facilities will be expanded to withdraw up to 48 ML/d of raw water (Table 6-1).

In practice, the flow through the process will fluctuate by about 10 to 20 percent, with the membrane system required to operate at higher instantaneous flux rate to compensate for various non-production operating modes such as membrane backwashing, forward flush, CIP/CEB cleanings, integrity testing, and so forth. As a result, downstream and upstream processes will be sized for the hydraulic capacity listed in Table 6-1. For Phase 2, the raw water intake capacity will be limited to 48 ML/d flow rate by the water license. Therefore, the membrane process will be expanded with provisions to maintain near-constant raw water flow and minimize flow fluctuations. These provisions require ERWS to purchase more membrane modules per ML/d of treated water so that trains in service can increase their individual flow to maintain a near constant WTP flow when other trains are offline (for example, for backwash). In Phase 1, there is excess intake capacity; therefore, it is not necessary to procure additional membrane modules that provides cost savings to the ERWS.

During commissioning, the plant will be operated at flows of up to 4 ML/d intermittently. Treated water flows will be diverted from the clearwell (without chlorine or pH adjustment) to the gravel pit through the WTP overflow. The WTP will be tested at capacity after the WTP is disinfected and finished water can be directed to the distribution system.

TABLE 6-1
ERWS WTP Flows

Parameter	Phase 1	Phase 2
Design production capacity (ML/d)	16	47.3
Average production capacity (ML/d)	12	24.9
Minimum production capacity (ML/d)	8	8
Plant hydraulic capacity (ML/d)	21.6	48

Notes:
Assumes membranes are procured in to minimize raw water flow variations
ML/d = megalitres per day

6.1.2 Process Considerations

Treatment processes include:

- Coagulation – Coagulation (with optional pH adjustment) is used in conjunction with membrane filtration for removal of color and disinfection by-product precursors.
- Vortex sand separators – The sand separators will remove sand and heavy suspended solids during high turbidity events.
- Fine strainers – The fine strainers will remove materials greater than 300 microns prior to membrane filtration.
- Membranes – UF membranes will remove suspended particles, including pathogens, turbidity, and coagulated coloured particles, from water. The membrane package supplied will have a minimum performance guarantee of 3-log removal of *Cryptosporidium* and *Giardia* and 0.5-log removal of viruses. The membrane system will consist of two filtration stages. The first (primary) stage will provide filtered water directly to the UV disinfection system. Spent backwash water from the primary stage will be equalized in UF backwash equalization tanks, filtered by a secondary-stage membrane system, and blended with the primary-stage filtered water prior to UV disinfection.
- UV disinfection – UV units downstream of the membranes will inactivate pathogens such as *Cryptosporidium* and *Giardia*. The design dosage will be 10 millijoule per centimetre squared (mJ/cm^2) based on 1-log *Cryptosporidium* inactivation.
- Chlorination – Chlorine will be applied to inactivate viruses (4-log minimum inactivation) and subsequently for residual maintenance in the distribution system.
- Corrosion control – Sodium hydroxide and carbon dioxide will be added to the treated water to raise the alkalinity to 30 mg/L and adjust pH to 9.2.
- Residuals – Process drains, neutralized chemical solutions, and backwash from the secondary-stage membrane will be equalized and pumped to the sewer.

Table 6-2 summarizes IHA treatment requirements and the WTP's treatment performance.

TABLE 6-2
Treatment Requirements and WTP Performance

Parameter	Virus Reduction	*Giardia* Reduction	Cryptosporidium Reduction	Turbidity Reduction (NTU)
IHA requirements	≥ 4 log (Σ)	≥ 3 log (Σ)	≥ 3 log (Σ)	< 0.1 (100% membrane)
Membrane UF/MF	≥ 0.5 log (I)	≥ 3 log (R)	≥ 3 log (R)	< 0.1 (IFE)
UV (7 mJ/cm^2)		1 log (I)	1 log (I)	
Chlorination (@ 1 °C)	> 4 log (I)			

Notes:
Σ = total I and R
IFE = individual filter effluent
NTU = nephelometric turbidity unit
UF/MF = ultrafiltration/microfiltration
IHA = Island Health Authority
I = inactivation
mJ/cm^2 = millijoule per centimetre squared
R = removal
UV = ultraviolet

Table 6-3 outlines which technologies are required for the contaminants listed above and differentiates between the primary barrier technology and the secondary barrier technology.

TABLE 6-3
Multi-Barrier Treatment

Contaminant	Primary Barrier	Secondary Barrier
Viruses	Membrane filtration	Chlorine disinfection
Cryptosporidium	Membrane filtration	UV disinfection
Giardia	Membrane filtration	UV disinfection

Note:
UV = ultraviolet

6.2 Intake and Raw Water Pump Station

6.2.1 Obermeyer Weir (future)

The minimum water depth at the intake site is too low (approximately 0.45 m) to extract the ultimate design flow from the river; therefore, a weir will be constructed in Phase 2 of the project. The proposed sizing and design of the weir is:

- Number of weir sections = 1
- Width of weir section = 3.5 m
- Low weir height (at 1.2 m^3/s In-stream flow) = 0.45 m
- Intake flow at 1.2 m^3/s in-stream flow = 24 ML/d
- Full weir height = 0.75 m
- Intake flow at full weir height = 48 ML/d

The weir will be raised or lowered by pressurizing or deflating an air bag beneath it. Pressurized air will be provided by an air compressor and receiver in the RWPS.

6.2.2 Intake Structure

The intake structure includes screens that will be designed to protect fish and other aquatic life at the intake, as well as to prevent debris from entering the raw water supply. The proposed sizing and design of the intake screen is:

- Number of screen panels = 4
- Screen slope = 1.5:1 (H:V)
- Effective screen length = 5.2 m
- Effective depth = 0.60 m (maximum)
- Effective screen area = 5.6 m^2 (at maximum depth)

The screens will be cleaned by an automated air backwash system consisting of air piping at the intake and a compressor/receiver unit (the same unit will be used for the Obermeyer weir) in the RWPS. Sizing of the compressor is shown in Section 6.2.3.

6.2.3 Raw Water Pump Station

The raw water pumps will feed raw water from the Englishman River to the WTP through the sand separators, fine screen, primary stage membranes, UV disinfection, and chlorine contact tank (CCT). Vertical turbine pumps in cans were selected to lift the water because of their high efficiency and to minimize the footprint of the pump station. Table 6-4 summarizes the design criteria for the raw water pump station.

TABLE 6-4
Raw Water Pump Station

Parameter	Phase 1	Phase 2
Minimum nominal capacity, ML/d	8	8
Firm nominal capacity, ML/d	16	48
Number of pumps	1 duty + 1 standby	3 duty + 1 standby
Nominal capacity of each pump, ML/d	16	16
TDH, m	49.1	60.9
Power of each pump, kW	150	150
Type of pump	Vertical turbine with VFD	Vertical turbine with VFD

Notes:
For each pump: discharge pressure gauges with manual isolation valve, discharge isolation valves, , strainer, magnetic flow metre and check valve.
Common discharge pressure transmitter
kW = kilowatts TDH = total dynamic head
ML/d = megalitres per day VFD = variable-frequency drive

6.2.3.1 Air Backwash System

The air compressor in the RWPS will provide pressurized air to operate the weir (Phase 2) and clean the intake screens. The proposed sizing and design of the air compressor is:

- Pressure in the air receiver = 1,240 kPa
- Water pressure above screen centreline = 40 kPa (4 m water depth)
- Additional air factor = 3
- Volume of compressor = To be confirmed in detailed design

6.2.3.2 Surge Suppression

If a power failure or other sudden failure of the raw water pumps occurs, water could flow back toward the RWPS and damage equipment. To mitigate this risk, a surge suppression bladder tank will be provided in the RWPS. The proposed sizing of the bladder tank will be determined in detailed design.

6.3 Feedwater Coagulant Addition

A high-basicity polyaluminum chloride coagulant will be added to the feedwater in the raw water main prior to the WTP. The coagulant pump will be sized for Phase 1 and the remaining infrastructure will be sized for Phase 2. The option of controlling pH with sodium hydroxide will be investigated during proof pilot testing. The coagulant will be used to reduce colour and dissolved organic carbon from the feedwater in conjunction with membrane filtration. Currently, a minimum contact time of 5-10 minutes is recommended although reduction in this time will be investigated during pilot testing. Coagulant dosages were determined via treatability testing. Table 6-7 summarizes design criteria for the coagulant feed system.

TABLE 6-5
Coagulant Feed System for Colour and Dissolved Organic Carbon Removal

Parameter	Phase 1	Phase 2
Coagulant type	High-basicity PACL	High-basicity PACL
Minimum contact time, min	5-10	5-10
Location of injection point	Raw water main (@ WTP site)	Raw water pump station
Average dose, mg/L	11.25	11.25
Dose range, mg/L	5–40	5–40
Average daily use, L	72	216
Type of pump	Peristaltic pump	Peristaltic pump
Number of feed pumps	1 duty, 1 standby	2 duty, 1 standby
Pump capacity-range, LPH	0.6–25	0.6-59
Carrier water	Yes, 1:5 ratio	Yes, 1:5 ratio
Storage type and number	Bulk storage, 1 tank	Bulk storage, 1 tank
Storage criteria average use, day	30	30
Storage capacity, L	20,000	20,000
Materials of construction	Wood stave with liner	Wood stave with liner
pH adjustment	TBD during proof pilot testing	TBD during proof pilot testing

Notes:
Final coagulation conditions will be optimized during proof pilot testing from December 2015 – April 2016 to determine final pH, coagulant dose, and contact time.
LPH = litres per hour
PACL = polyaluminum chloride
TBD = to be determined

6.4 Sand Separators and Fine Strainers

UF systems are designed to filter small suspended solids and particles. A pre-strainer is typically used to remove particles larger than 300 microns. For the ERWS source water, sand separators are recommended upstream of the strainers to manage larger loads of sand and suspended solids during storm events without compromising the performance of downstream processes. Tables 6-5 and 6-6 summarize primary design criteria for the sand separators and fine strainers.

TABLE 6-6
Design Criteria for Sand Separators

Parameter	Phase 1	Phase 2
Expected headloss, kPa	48	48
Type	Vortex	Vortex
Supplier	Lakos	Lakos
Number of separators	3 (2 duty + 1 standby)	7 (6 duty + 1 standby)
Nominal capacity of each separator, ML/d	8	8

Notes:
kPa = kilopascal
ML/d = megalitres per day

TABLE 6-7
Design Criteria for Self-Cleaning Strainer or Screen

Parameter	Phase 1	Phase 2
Screen size, µm	300	300
Expected headloss, kPa	34.5	34.5
Type	Self-cleaning strainer with external backwash source	Self-cleaning strainer with external backwash source
Supplier	Amiad	Amiad
Number of strainers	2 (1 duty + 1 standby)	5 (3 duty + 2 standby)
Nominal capacity of each strainer, ML/d	16	16

Notes:
kPa = kilopascal
ML/d = megalitres per day
µm = micrometre

6.5 Ultrafiltration System

The UF system will have the following major components:

- UF feed pumps (primary stage uses raw water pumps described under Section 6.2)
- UF modules and rack assembly
- Air compressor system
- Backwash and air scour system
- Chemical-enhanced backwash system
- CIP system

6.5.1 Feed Pumps

The UF feed pump system is pressure-driven; therefore, the raw water pumps (see Table 6-1) will be used to pressurize feedwater to the primary stage UF. The spent backwash water from the primary stage membranes will be equalized in a basin, and vertical-turbine-type booster pumps will feed the secondary-stage membranes.

6.5.2 Membranes and Membrane Assembly

The WTP will use membrane ultrafiltration technology in an outside-in flow configuration in pressurized modules. Toray HFU-2020N ultrafiltration membranes from the membrane system supplier (MSS) H2O Innovation were chosen following evaluation of proposals received in response for a Request for Proposals to furnish a membrane filtration system for the ERWS WTP. Proposals from three suppliers were received and evaluated in October, 2015. General design criteria for the membrane and fouling management systems are provided in Tables 6-8 and 6-9, respectively.

TABLE 6-8
Membrane Fouling Management Criteria

Parameter	First Stage	Second Stage
Backwash interval (min)	30-45	15
Backwash duration (min)	1	1
Air scour duration (min)	0.5	0.5
Chlorine CEB interval (d)	1	1
Chlorine CEB duration (min)	30	30
Chlorine CEB chemistry	100 mg/L chlorine	100 mg/L chlorine
Acid CEB interval (d)	7	7
Acid CEB duration (min)	30	30
Acid CEB chemistry	500 mg/L sulfuric acid	500 mg/L sulfuric acid
Chlorine CIP interval (d)	45	45
Chlorine CIP duration (hr)	4	4
Chlorine CIP chemistry	1,000 mg/L chlorine	1,000 mg/L chlorine
Acid CIP interval (d)	45	45
Acid CIP duration (hr)	4	4
Acid CIP chemistry	2000 mg/L citric acid pH = 2	2000 mg/L citric acid pH = 2
MIT interval (d)	1	1
MIT duration (min)	20	20

Notes:
CEB = chemical-enhanced backwash
CIP = clean in place
d = days
MIT = membrane integrity testing
At design capacity (16 ML/d) CEBs performed daily (6 days a week chlorine, 1 day a week acid)

TABLE 6-9
Encased MF/UF System Key Design Criteria

	Phase 1		Phase 2	
	Primary Stage	**Secondary Stage**	**Primary Stage**	**Secondary Stage**
Design UF permeate flows each rack, ML/d	5.97	0.67	9.0 (new racks only)	1.2 (new rack only)
Design max. Instantaneous flux @ 14 °C, LMH	84.2	51.2	84.2	51.2
Recovery, %	96	> 75	96	> 75
Overall recovery (both stages), %	99		99	
Maximum transmembrane pressure, kPa	200	200	200	200
Number of skids	4 (3 duty, 1 standby)	1 (1 duty)	9 (8 duty, 1 standby)	2 (1 duty, 1 standby)
Number of modules installed per skid or rack	45	10	TBD	TBD
Number of module spaces available per skid or rack, %	15.6	50	10	10
Module surface area, m^2	72	72	72	72
Membrane Characteristics				
Membrane type	UF	UF	UF	UF
Module manufacturer and model	Toray HFU-2020N	Toray HFU-2020N	Toray HFU-2020N	Toray HFU-2020N
Membrane material	PVDF	PVDF	PVDF	PVDF
Nominal pore size, µm	0.02	0.02	0.02	0.02
Membrane life expectancy, years	10	10	10	10
Operating mode	Deposition	Deposition	Deposition	Deposition
Module orientation	Vertical	Vertical	Vertical	Vertical
Maximum operating pH	11	11	11	11
Maximum operating temperature, °C	40	40	40	40

Notes:
1. See Table 6-2 for UF performance requirements.

°C = degrees Celsius
m^2 = square metres
TBD = to be determined
PVDF = polyvinylidene fluoride
LMH = litre/m^2/hr
UF = ultrafiltration
LMH = litre per metre squared per hour

6.5.3 Ancillary Equipment

The following ancillary equipment will be sized to accommodate the smaller membrane racks in Phase 1 and the larger membrane racks in Phase 2:

- Backwash system
- CEB/CIP/Neutralization system
- Compressors and Blowers
- Waste Equalization Tank

6.5.4 Backwash System

The backwash system will consist of backpulse pumps with variable-frequency drives (VFDs), strainers on the pump discharge, air scour blowers, and associated piping, valves, and controls for removing solids from the membrane modules. The backpulse pumps will draw filtrate from the clearwell. The primary- and secondary-stage membranes will use the same backwash pumps and blowers. Tables 6-10 and 6-11 summarize the design criteria.

TABLE 6-10
Design Criteria for Backwash System

Component	Item	Description
Rotating equipment	Type	Backwash pump: vertical turbine, high-efficiency motor with VFD
	Design criteria	200 m^3/hr at 30 m TDH, 37.3 kW motor at 900 rpm (to be updated by MSS)
	Manufacturer	Goulds
	Number	2 pumps; 1 duty, 1 standby
	Other	Alternate duty pump every 1–3 hours (automatic) 1 witch-hat-type strainer per pump, magnetic flow meter for common discharge
Process tanks	Design criteria	Dedicated 13.7 m^3 volume in CCT (see Section 6.7) (to be updated by MSS)
	Other	Ultrasonic level transmitter, low-level switches
Water quality monitoring		Not required
Others		Service water connection Point for future chlorine injection

Notes:
For each pump, discharge pressure gauges with manual isolation valves, discharge isolation valves, discharge pressure transmitter, strainer and check valve.
Common discharge magnetic flow meter.
A service water connection from the town will be provided to the CCT as a supply during startup and prolonged plant shutdowns.
CCT = chlorine contact tank
kW = kilowatts
m^3/hr = cubic metres per hour
MSS = membrane system supplier
rpm = revolutions per minute
TDH = total dynamic head
VFD = variable-frequency drive

TABLE 6-11
Design Criteria for Air Scour System

Component	Item	Description
Rotating equipment	Type	Positive displacement blower with VFD
	Manufacturer	Aerzen GM Series
	Design criteria	11.2 kW motor
	Number	2 blowers; 1 duty, 1 standby Provide mass flow meter in common blower discharge
Process tank	Type	Not required
Water quality monitoring		Not required
Other		Acoustical enclosure

Note:
MSS = membrane system supplier kW = kilowatts
VFD = variable-frequency drive

6.5.5 Residuals

Residuals from the WTP building will be equalized, stored, and disposed as outlined below (design criteria are summarized in Tables 6-12 to 6-13):

- Membrane break tank – Equalization of backwash from the primary-stage membranes. Flows are pumped to the secondary-stage membranes.
- Sand separator blow-down to WET.
- Waste equalization tank – Equalization of backwash from the secondary-stage membranes, fine strainer backflush water, sand-separator blow-down, neutralized spent chemical solutions from primary- and secondary-stage membranes, and analyzer drains. Flows are pumped to the sewer. Sanitary flows from the washrooms would not be directed to the WET.
- Stormwater Pond – Collects rain water from the WTP rooftop. Overflows directed to overflow structure.
- Overflow structure – Directs overflows from the WTP into the gravel pit. Flows include overflows from stormwater pond, overflows from the clearwell, temporary commissioning line, and flushing flows.

TABLE 6-12
Design Criteria for UF Backwash Break Tank

Component	Item	Description
Rotating equipment	Type	Secondary-stage feed pump: vertical turbine, high-efficiency motor with VFD
	Design criteria	85 m^3/hr at 30-m TDH, 15-kW motor at 1,200 rpm (to be updated by MSS)
	Number	2 pumps; 1 duty, 1 standby
Process tanks	Type	Below-grade, reinforced concrete with sump, access point on top, hose-down station nearby, and vent to outside
	Design criteria	minimum 23.2 m^3 effective volume (60-min equalization @ 16 ML/d)
	Number	1 tank
	Other	Ultrasonic level transmitter and high- and low-level switches
Water quality monitoring		Turbidimeter

TABLE 6-12
Design Criteria for UF Backwash Break Tank

Component	Item	Description

Notes:
For each pump: discharge pressure gauges with manual isolation valves, discharge isolation valves, discharge pressure transmitter, and check valve.
Common discharge magnetic flow meter.
m^3 = cubic metres   ML/d = megalitres per day
MSS = membrane system supplier   TDH = total dynamic head
VFD = variable-frequency drive

TABLE 6-13
Design Criteria for Waste Equalization Tank

Component	Item	Description
Rotating equipment	Type	Vertical turbine, fixed speed
	Design criteria	35 m^3/hr (TDH, motor speed and power to be defined by MSS)
	Number	2 pumps; 1 duty, 1 standby
	Other	Sewer capacity is less than 10 L/s
Process tanks	Type	Below-grade, reinforced concrete with sump, access point on top and side, hose-down station nearby, and vent to outside
	Design criteria	minimum 32.54-m^3 effective volume (90-min equalization @ 16 ML/d)
	Number	1 tank
	Other	Ultrasonic level transmitter and high-level switch
Water quality monitoring		Not required

Notes:
For each pump: discharge pressure gauges with manual isolation valves, discharge isolation valves, discharge pressure transmitter, and check valve.
Common discharge magnetic flow meter.
kW = kilowatts   rpm = revolutions per minute
ML/d = megalitres per day   WET = waste equalization tank
TDH = total dynamic head

6.5.5.1 CEB/CIP/Neutralization System

The chemical-enhanced backwash (CEB)/CIP/Neutralization system will consist of process tanks, a permeate heating system, recirculation pumps and associated piping, valves, monitoring equipment, and controls for controlling and removing membrane fouling and neutralizing and disposing of chemical solutions and flush water. Table 6-14 summarizes the design criteria.

TABLE 6-14
Design Criteria for CEB/CIP/Neutralization System

Component	Item	Description
Rotating equipment	Type	recirculation pump: end suction centrifugal, FRP or Type 316L SS construction, VFD
	Design criteria	recirculation pump, 18.7 kW
	Number	Recirculation: 2 pumps per tank; 1 duty, 1 standby
	Manufacturer	Grundfos

TABLE 6-14
Design Criteria for CEB/CIP/Neutralization System

Component	Item	Description
Process tanks	Type	Above-grade, FRP or HDPE
	Design criteria	24.2-m^3 effective volume
	Number	2
	Other	Ultrasonic level transmitters. Provide containment area. Provide hose-down station nearby. Tank overflow into WET. Tanks vented to outside.
Water quality monitoring		Temperature, pH, chlorine
Other		Immersion heater capable of heating water in 4 hours from 2 to 40 degrees C. Double block and bleed valves provided on each tie-in point between the cleaning system and the membrane racks
		End neutralization cycle when both pH and chlorine are within 15% of setpoint (pH = 7, chlorine residual < 0.1 mg/L)

Notes:
CIP or CEB volumes are assumed to be 10 m^3 including volume in membrane train, modules, train piping, and recirculation piping. Neutralization volume is assumed to be 16 m3. Design criteria to be updated by MSS.
For each pump: suction and discharge pressure gauges with manual isolation valves, suction and discharge isolation valves, discharge pressure transmitter and check valve.
Common discharge magnetic flow meter.
A service water connection will be provided for each analyzer to maintain a sample flow when the tanks are not in use.
CEB = chemical-enhanced backwash
CIP = clean in place
FRP = fibre-reinforced plastic
HDPE = high-density polyethylene
m^3 = cubic metres
VFD = variable frequency drive
WET = waste equalization tank

6.5.5.2 Membrane Preservative Removal and Disposal

The Toray HFU-2020N membrane modules are shipped preserved in a dilute bisulphite solution that will need to be removed via flushing before operation.

6.5.5.3 Membrane Removal Device and Membrane Repair

A ‘FiberMove’ membrane removal device will be provided. Space provided between the racks will allow access with the FiberMove device.

6.5.5.4 Chemical Metering and Storage System for Membranes

Five chemical systems will be involved in the membrane treatment process: citric acid, sulphuric acid, sodium bisulphate, sodium hydroxide, and sodium hypochlorite. Criteria for chemical delivery and storage are summarized in Section 6.9.

6.5.5.5 Compressed Air Systems

The automated valves used throughout the membrane system will use pneumatic actuators. Compressed air will be required for valve actuation and the MIT system. An integrated compressed air system will be provided for the entire system. Table 6-15 summarizes the design criteria.

TABLE 6-15
Design Criteria for Compressed Air System

Component	Item	Description
Rotating equipment	Type	Rotary screw air compressor
	Design criteria	3.7 kW motor; 3.5 SCFM/module
	Number	2 (1 duty, 1 standby)
	Manufacturer	Quincy
Process tank	Type	1 x 1,500-L receiver
Air quality monitoring		Dew point analyzer, pressure transmitter for valve actuation
Other		Pressure-regulated 550 kPa Desiccant dryer for actuator air; wet air for MIT

Notes:
MIT = membrane integrity testing
SCFM = standard cubic feet per minute

6.6 Ultraviolet Disinfection

An ultraviolet (UV) disinfection system will be provided for primary inactivation of *Cryptosporidium* and *Giardia*. The system furnished by the UV supplier will include pre-validated UV reactors, UV reactor power supply/control panels, power supply line filters, transient voltage surge suppressors, ballasts/transformers, medium pressure lamps, quartz sleeves, calibrated duty and reference UV sensors, automatic cleaning system, cleaning chemicals, electrical conduit and control wiring within the UV reactor and power/control cabinet(s), UV transmittance monitor, UV reactor water level and temperature sensors, for a complete and operable system. Only UV reactors utilizing medium-pressure lamps will be considered. The primary design criteria for the UV system are given in Table 6-16.

TABLE 6-16
Design Criteria for UV

Parameter	Phase 1
Design UV dose, mJ/cm^2	10
Maximum flow rate, ML/d	16 (21.6 peak)
UVT, %	80 (75–95)
Performance requirement	1-log *Cryptosporidium* and *Giardia* inactivation
Lamp output (due to aging and fouling), %	80
Redundancy	2x300mm reactors (1 duty + 1 standby, normal operation is 2 duty to minimize headloss)
Cleaning system	Automated mechanical cleaning
Valves and flow meters per reactor	2x300 mm isolation valves and 1x300mm flow meter, 1x 50 mm drain valve, 1 air relief valve.
Total headloss per train	85 cm @ design flow
Intensity sensors, number	1 per reactor
UVT Analyzer	1 common sampling from the membrane permeate header

Notes:
mJ/cm^2 = millijoules per square centimetre
mm = millimetre
ML/d = megalitres per day
UVT = ultraviolet transmittance

6.7 Chlorine Disinfection and Corrosion Control

Post-treatment will include addition of chlorine for disinfection and residual maintenance, and addition of sodium hydroxide and carbon dioxide for corrosion control, as listed below. The CCT will consist of two cells in series. The first cell will provide backwash water supply to the membranes (see Table 6-10) and the second cell will be sized for 4-log virus inactivation. Water from the CCT will overflow into the clearwell, which will incorporate flow equalization volumes. Design criteria are summarized in Tables 6-17 and Table 6-18. The following summarizes the post-treatment chemical additions:

- Addition of sodium hypochlorite for virus inactivation and carbon dioxide for pH adjustment at the entrance of the CCT.
- Addition of sodium hydroxide and sodium hypochlorite before the weir from the CCT into the high lift pump wet well. This injection points will be used for Phase 1 and Phase 2. Sodium hydroxide is added to raise the alkalinity to greater than 30 mg/L as $CaCO_3$ and adjust pH to 9.2. Sodium hypochlorite is added for residual maintenance in the distribution system.

Sodium hydroxide and CO2 dosages were determined using WaterPro modelling software and confirmed via treatability testing. Sodium hypochlorite dosages were determined from chlorine demand and decay treatability testing. The health-based limit for sodium in drinking water is 200 mg/L, although it is general practice to stay below the medical officer of health notification requirement of 20 mg/L. This requirement notifies doctors to advise patients with sodium-reduced diet that their drinking water sodium levels could be greater than 20 mg/L. Considering the raw water quality and the addition of sodium from sodium hypochlorite and sodium hydroxide, the ERWS-finished water would remain below the notification level. If sodium hydroxide is added for coagulation then less will be added for corrosion control such that the total amount of sodium hydroxide would remain the same as if all was added for corrosion control.

The CO2 will be stored in liquid form, vaporized and pre-dissolved in carrier water with a sparger and injected into the CCT using a diffuser. The liquid CO2 system equipment (storage vessel, vaporizer, and associated piping) will be owned and maintained by the chemical supplier under a lease agreement with ERWS. The rationale for dosing CO_2 as a liquid rather than a gas is that dosing as a gas at the bottom of the tank raises the potential for off-gassing due to the relatively shallow tank depth. This would present a significant health and safety issue for the plant staff. CO_2 gas is colourless, odourless, and tasteless. In a confined space, a CO_2 leak will displace oxygen necessary to support life. CO_2 is naturally present in the atmosphere at the levels of approximately 350 ppm. The CO_2 concentration in the fresh air varies between 300 ppm to 600 ppm, depending on location and in exhaled air at approximately 450 ppm. There is a sharp nasal sensation at high concentration. Ambient CO_2 monitors will be provided near the control panel and application points. The CO_2 gas concentrations would be monitored and trended on SCADA with alarms set below the OSHA permissible levels for 8 hour exposures of 5,000 ppm or 0.5%.

TABLE 6-17
Design Criteria for Corrosion Control

Parameter	Phase 1
Raw water alkalinity, mg/L $CaCO_3$	< 12
Treated water alkalinity, mg/L $CaCO_3$	30
Raw water pH	6.5–7.9
Treated water pH	9.2
Sodium Hydroxide Dose (mg/L)	5 - 15
Carrier water	1:5 ratio
Daily consumption (kg/d)	See Section 6.9

TABLE 6-17
Design Criteria for Corrosion Control

Parameter	Phase 1
Storage	See Section 6.9
Carbon Dioxide Dose (mg/L)	1 - 11
Carrier water	8.3 LPM of water per kg/hr of CO2
Daily consumption (kg/d)	See Section 6.9
Storage	See Section 6.9

Note:
$CaCO_3$ = calcium carbonate
kg/d = kilograms per day

TABLE 6-18
Design Criteria for Chlorine Addition

Parameter	Phase 1
Primary Disinfection	
Inactivation target	4-log reduction of viruses
Temperature, °C	0.5
Nominal water flow, ML/d	16
Ratio of actual CT to required CT	> 1
Design basin efficiency	0.6
Minimum chlorine residual, mg/L	1
Total effective volume, m^3 [a]	345
Dose (mg/L)	0–2
Daily consumption (kg/d)	See Section 6.9
Storage	See Section 6.9
Secondary Disinfection – Residual Maintenance	
Dose (mg/L)	0–1
Daily consumption (kg/d)	See Section 6.9
Storage	See Section 6.9

Notes:
Total volume only incorporates inactivation. Other volumes are accounted for in the clearwell. Actual volume of CCT will be 345 m3, assuming 5.75 m depth.
Full flow overflow provided at the CCT (21.6 ML/d for Phase 1, 48 ML/d combined for Phases 1 and 2)
Water quality monitoring: 1 chlorine and 1 pH analyzer at the end of the CCT prior to caustic and carbon dioxide addition.
°C = degrees Celsius   CT = concentration*contact time
kg/d = kilograms per day   ML/d = megalitres per day

6.8 High Lift Pump Station

6.8.1 High Lift Pump Design Criteria

The finished water from the CCT will overflow into the clearwell (high lift pump wells), then be pumped to two distribution system pipelines: W1, which sends water to RDN, and W2, which sends water to the north end of the distribution system in Parksville. The design criteria for the high lift pumps are given in Table 6-19.

TABLE 6-19
High Lift Pump Wet Well Design Criteria

Component	Item	Description
Process tank	Type	Below-grade, reinforced concrete with sump, access point on top, hose-down station nearby, and vent to outside.
	Design criteria	280 m^3 effective volume (0% fire storage, 0% emergency storage, 1% flow equalization storage)
	Number	1
Water quality monitoring		1 chlorine residual and 1 pH analyzer in discharge of high lift pumps
Other		Ultrasonic level transmitters, low- and high-level flow switches; overflow to overflow structure

Note:
Phase 2 will include additional clearwell volume

m^3 = cubic metres

TABLE 6-20
High Lift Pump Station Design Criteria

Parameter	Phase 1	Phase 2
Capacity, ML/d	8 (minimum) 21.6(maximum)	8 (minimum) 48 (maximum)
Number of pumps	1 duty + 1 standby	3 duty + 1 standby
Nominal capacity of each pump, ML/d	16	16
TDH, m	52	56
Power of each pump, kW	261	261
Type of pump	Vertical turbine with VFD	Vertical turbine with VFD

Notes:
For each pump: discharge pressure gauges with manual isolation valve, discharge isolation valve, discharge pressure transmitter, strainer and check valve.
Discharge magnetic flow meter for each high lift pump.
ML/d = megalitres per day TDH = total dynamic head
VFD = variable-frequency drive

6.8.2 Surge Suppression

If a power failure or other sudden failure of the raw water pumps occurs, water could flow back toward the HLPS and damage equipment. To mitigate this risk, a surge suppression bladder tank will be provided on the discharge header to the distribution system. The proposed sizing of the bladder tank will be confirmed in detailed design.

6.8.3 Process Service Water

Service water for process equipment and instrument, hose reels, and wash down will be provided from the high lift pump station discharge header (metered). A connection to the new potable service water connection will be provided for initial commissioning. All other potable water needs including water fixtures, hot water, and eyewash stations will be supplied from the new potable service water connection from the yard. If a power failure or other sudden failure of the raw water pumps occurs, water could flow back toward the HLPS and damage equipment.

6.9 Chemical Systems

This section describes the design of the chemical systems, which include citric acid, sulphuric acid, carbon dioxide, sodium bisulphate, sodium hydroxide, and sodium hypochlorite. A chemical room will be located on the east side of the WTP. All chemical storage, metering, spill containment, and controls will be in the chemical room within a secondary containment area for each chemical. This will help contain any chemical spills from a malfunctioning pump or pipe leak, and will also facilitate maintenance.

Delivery of chemicals stored in tanks will be to the delivery point on the west side of the WTP. Delivery of chemicals in totes can also be via access doors on the north and south side of the WTP. Features will include:

- One common fill pipe for each chemical bulk tank or set of tanks for a particular chemical system
- Delivery area panels where the liquid levels of all storage tanks will be displayed and high-level alarmed
- Spill containment in the delivery area, which will include a sump pit, grates, a level sensor, and a drain relying on a pump or gravity flow for emptying
- A 6,000-litre buried plastic chemical waste storage tank will be provided to collect spills from the chemical containment areas and the loading area

Components common to all the chemical systems will include:

- Chemical delivery, including dedicated chemical fill line and associated manual shut-off valve
- Storage tank(s) with level sensor and sight gauge
- Duty and standby chemical metering pumps

6.9.1 General

Chemicals will be dosed from the chemical storage and metering areas to the point or points of application through single-wall piping. Water-tight fibre-reinforced polymer (FRP) trays will provide secondary containment of chemical piping and a way to prevent and detect releases to the environment. Chemical dosing and control is described for each chemical in the subsequent sections.

6.9.2 Storage and Secondary Containment

Chemical storage tanks will be sized considering:

- 30-day chemical use for Phase 1
- The size of bulk chemical delivery trucks (approximately 20,000 litres)
- Deterioration rate of some chemicals (such as sodium hypochlorite)

Storage requirements and annual usage are summarized in Tables Table 6-21 and Table 6-22. Bulk storage tanks will be constructed of painted carbon steel with a polyethylene bag liner and side access hatches or wood stave with a bag liner. The tank will include an ultrasonic level sensor, a manual drain valve, an overflow with a water trap, and a vent to the outside through dedicated dry scrubbers. Access to the top of the chemical tanks will be provided by a catwalk common to all tanks and accessed by stairs.

For chemicals requiring small storage volumes, a 1,500-litre tank will be provided. The tank will be permanently located on a structural frame (FRP or painted carbon steel) where a 1,000-litre tote can be stacked and drained into the permanent tank. Instrumentation, drains, vents, and overflow features will be the same as for the large bulk storage tanks.

Secondary containment areas will be designed to hold 110 percent of the largest tank's volume. They will be sunken concrete structures with a chemical-resistant coating and FRP grating above the containment area (throughout) for access at grade. A sump will be provided to pump wash down water and spills into a vac truck or the chemical waste storage tank with a portable submersible pump.

TABLE 6-21
Chemical Storage Requirements

Chemical	Average Use (L/d)	Peak Use (L/d)	Tank Volume (L)	Storage, Phase 1 (Days)	
				Average Use	Peak Use
Sodium hypochlorite (12% w/w)	140.25	231.42	2 x 5,000	70	43
Sodium hydroxide (50% w/w)	123.77	204.22	1 x 20,000	159	97
Sulfuric acid (93% w/w)	0.13	0.13	1 x 200	1,565	1,565
Citric acid (50% w/w)	1.33	1.33	1 x 200	148	148
Sodium bisulphite (38% w/w)	2.49	2.49	1 x 200	79	79
Coagulant (100% w/w)	71.93	179.78	1 x 20,000	274	110
Carbon dioxide (98% w/w)	59.97	110.45	6-ton cylinder	99	54

Notes:
Tank volumes include the effective volume required for chemical storage plus 600 mm for dead volume, freeboard, and overflows.
Chemical use to be updated after proof pilot testing (December 2015 – February 2016).
L/d = litres per day
% w/w = mass percentage

TABLE 6-22
Estimated Annual Chemical Use (Phase 1)

Component	Pre-treatment (L)	Membranes (L)	Post-Treatment (L)
Sodium hypochlorite (12% w/w)		2,087	49,493
Sodium hydroxide (50% w/w)		564	44,963
Sulfuric acid (93% w/w)		46	–
Citric Acid (50% w/w)		485	–
Sodium Bisulphite (38% w/w)		909	–
Coagulant (100% w/w)	26,253	–	–
Carbon dioxide (98% w/w)		–	21,889

Notes:
% w/w = mass percentage

6.9.3 Chemical Metering

Peristaltic pumps will be used for all liquid treatment chemicals, and an educator and dissolution system will be used for carbon dioxide. Chemicals used for membrane cleaning and neutralization of spent cleaning solutions will be transferred using diaphragm metering pumps. Each pump will be equipped with a magnetic flow meter and transmitter to monitor the chemical flow rate. Duty and standby pumps will be provided for each chemical. Pump design criteria are summarized in Table 6-23. Chemical pumps will be mounted in panels at the above the containment areas.

TABLE 6-23
Design Criteria for Chemical Pumps (Phase 1)

Chemical	Application Point	Chemical Dose Range (mg/L)	Chemical Pump Flow Range (LPH)	Carrier Water
Sodium hypochlorite (12% w/w)	Membrane CEB/CIP	100-1000	To be defined by MSS	No
Sodium hypochlorite (12% w/w)	Virus inactivation	1–2	2.2–11.97	No
Sodium hypochlorite (12% w/w)	Distribution system	0.25–1	0.56–5.99	No
Sodium hydroxide (50% w/w)	Membrane clean solution neutralization	38-875	To be defined by MSS	No
Sodium hydroxide (50% w/w)	Corrosion control	5–15	2.18–17.61	Yes
Sodium hydroxide (50% w/w)	Membrane feed	TBD	TBD	Yes
Sulfuric acid (93% w/w)	Membrane cleans and neutralization	325	To be defined by MSS	No
Citric acid (50% w/w)	Membrane cleans	2000	To be defined by MSS	No
Sodium bisulphite (38% w/w)	Membrane clean solution neutralization	103-1,027	To be defined by MSS	No
Coagulant (100% w/w)	Membrane feed	5–40	1.23–26.6	Yes
Carbon dioxide (98% w/w)	Corrosion control	1–11	0.33–9.9	Yes

Notes:
Chemical pump flows for continuous chemicals based on treatment water flows of 8 – 21.55 ML/d.
CEB = chemical-enhanced backwash
CIP = clean in place
LPH = litres per hour
% w/w = mass percentage
MSS = membrane system supplier

6.10 Water Quality and Ambient Air Monitoring

This section summarizes the water quality monitoring to be done for the WTP. Online analyzers for each process are listed in Table 6-24. Manual sample taps will be provided as follows:

- All online analyzers
- Two membrane racks, one primary, one secondary (all streams)
- Backwash and cleaning process tanks (CIP, hot water, backpulse, backwash)
- All process waste streams

TABLE 6-24
Water Quality and Ambient Air Monitoring

Component	Subsystem	Number of analyzers (Phase 1)
Laser turbidimeter	Membrane rack permeate	5 (1 per rack)
Online color analyzer	Combined membrane permeate	1
Chlorine analyzer	Membrane CEB/CIP/neutralization	1
	Finished water from CCT	1
	Finished water from discharge of high lift pumps	1
pH analyzer	Membrane feed water	1
	Membrane CEB/CIP/neutralization	1
	Finished water from CCT	1
	Finished water from discharge of high lift pumps	1
UVT analyzer	Combined membrane permeate	1
Temperature	Membrane feed water	1
	Membrane CEB/CIP	1
Ambient CO2 monitors	In HLPS Room	1
	Dissolution control panel	1

Notes:
CCT = chlorine contact tank
CEB = chemical-enhanced backwash
CIP = clean in place
UVT = ultraviolet transmittance
WET = waste equalization tank

Discipline Design

7.1 Process Mechanical

7.1.1 Introduction

This section describes the process mechanical discipline basis of design. All mechanical work associated with the treatment plant will comply with the following basis of design and with the applicable requirements.

7.1.2 Process Mechanical Design Approaches

Applicable Codes and Standards

The process mechanical design will make use of applicable industry standards and design guidance for piping, valves, and process equipment. The following is a list of the more significant resources for design and specification standards:

- American Water Works Association (AWWA)
- American Society of Mechanical Engineers (ASME)
- American National Standards Institute (ANSI)
- Hydraulic Institute (HI)

7.1.3 Layout and Access

The following conventions and guidelines will be followed to make the ERWS WTP optimally functional, operable, and maintainable:

7.1.4 Equipment

- Typically, one type of equipment will be chosen as the basis of design. This make or model is referred to as the “design standard.” Layout will be based on this selection. Where other manufacturers’ products are also suitable, the layout will be checked to ensure that the arrangement does not preclude the use of these alternatives

- Required space for equipment removal/replacement/maintenance will be provided in the layout on the drawings

- All equipment and associated panels and cabinets will be located on reinforced concrete equipment bases that are a minimum of 150 mm high and that extend 75 mm outside the equipment, panels, or cabinets

- A minimum clearance on sides around rotating equipment of 1 m will be provided. This minimum clear space also will allow equipment and piping to be completely removed and replaced without dismantling building sections or adjacent equipment and piping

- At least 1 m of clearance will be provided between the outermost extremities of adjacent pieces of equipment or between a wall and a piece of equipment
- Clearance in front of any other equipment face or panel requiring maintenance of 1.2 m will be provided
- For pumps, compressors, and other rotating equipment where parallel units are provided, the orientation of the drive and the rotation will be identical
- Stairs, catwalks, platforms, and hatches will be provided for accessing and removing equipment for maintenance and operation
- Adequate lifting headroom for equipment will be provided. An allowance for sling length or lifting beams between equipment lift points and crane or hoist hook also will be provided
- Wash down stations will be placed in logical areas to facilitate cleanup and pipe flushing.

7.1.5 Piping and Valves

- Piping will be located so that it is not a tripping hazard, a head-banger, or a barrier to equipment access. A minimum of 3 m of vertical clearance will be provided from the floor to the centreline for all piping that could impinge on equipment access. A minimum of 2.4 m of vertical clearance will be provided above the finished floor for piping that might limit personnel access
- Minimal piping will be located above blowers, compressors, or pumps to facilitate lifting
- In general, piping will be located close to walls where it can be easily supported, particularly in spaces with high ceilings
- Piping exiting the building will be within 3 m of grade
- If piping must be run close to a wall, but not supported from it, at least 600 mm of clearance will be provided between the outermost pipe flange and the wall
- To permit purging of air from the pipeline while it is being filled with water, a manual vent valve will be provided on the highest point of every pipeline to be filled with liquid or which is to be hydrostatically tested
- To permit water drainage, a manual drain valve will be provided on the lowest point of every pipeline
- Pipe supports and seismic bracing will generally not be shown on the layout drawings. However, it will be verified that adequate space is available for installation of these supports
- Flexible/removable connections will be provided to permit easy assembly and disassembly of piping and connections to equipment
- Anchors and expansion joints will be shown on the drawings
- If piping reducers are required on the suction side of pumps, eccentric reducers that are flat on top (FOT) will be provided
- Wall penetrations will be perpendicular to the wall

- Where reasonably possible, valves will be located within operator reach (below 2.4 m). For any valve over 2.4 m on the operating floor, a chain operator will be provided
- Swing check valves will not be located in vertical piping runs
- An easy disassembly coupling or pipe joint will be installed within four diameters of valves
- Thrust restraint for sleeve and other couplings that are not capable of internal thrust restraint will be provided
- Ample space for valve and gate actuators will be allowed for
- Adequate clearances for rising stem valves and gates will be provided
- Sufficient straight runs for flow meters and other instrumentation and controls (I&C) elements will be provided

7.1.6 Pumping Systems

7.1.6.1 Definitions

The following definitions will apply to the pump applications described in this section (not all types of liquids are present in this project):

- “Clear” liquids are those containing only minute quantities and particles of suspended solids (0.25 mm or less)
- “Reasonably clear” water will mean water containing either dissolved solids or fine suspended solids (0.5 mm or less), or both constituents
- “Sludge” is the residue recovered from a settled or filtered waste
- “Diluted sludge” is sludge to which water has been added to facilitate pumping
- Where a choice of pumping either “clear” or “reasonably clear” water or other liquids is given, closed impellers will generally be used for clear and reasonably clear fluids and open impellers should be used for sludge, and diluted sludge

7.1.7 Pump Types and Applications

The following general descriptions of pumps and their applications will apply:

7.1.7.1 Centrifugal Pumps – General

Centrifugal pumps will be used to move large flows at low to moderate heads. All centrifugal pumps will be equipped with a drip tray and drain connection.

7.1.7.2 Submersible Non-Clog Pumps

Submersible non-clog pumps will be used for standard sumps. Minimum sphere passage will be 100 mm.

7.1.7.3 Horizontal End Suction Centrifugal Pumps

Horizontal end suction centrifugal pumps will be used for pumping or circulating clear or reasonably clear water.

Gear pumps will be used for chemical systems.

7.1.7.4 Sample Pumps

All pumped sampling systems will be constructed of potable water quality materials for return to source.

7.1.8 Pump Speeds

Pump speeds will not exceed 1,750 rpm. Slower speeds are desirable for noise and NPSHr considerations particularly in 75 kW sizes or larger.

7.1.9 Pump Shaft Sealing

7.1.9.1 Seals and Packing

Generally, pumps will be furnished with mechanical seals, not packings. Single seals will suffice for most applications. Packings will not be considered for pump shaft sealing because of generally greater maintenance requirements than for mechanical seals. External flushing with seal water will be required for services other than clear water.

7.1.9.2 Mechanical Seals

Seals will be high quality, split mechanical, cartridge type Chesterton or equivalent.

7.1.9.3 Bearing Rating Lives

The minimum antifriction (rolling element) bearing rating life (B-10 Life) for this project is to be specified as 100,000 hours for 24-hour continuous duty and maximum reliability.

7.1.9.4 Couplings

Couplings will be spring-grid or gear type flexible couplings with Occupational Safety and Health Administration (OSHA) coupling guard for pumps, which carry their own thrust load.

7.1.9.5 Critical Speed and Vibration

The critical speed of all rotating members and the critical speed frequency of the motor will be at least 25 percent above the maximum motor operating speed.

Vibration levels of the pumping unit, when it has been installed on the structural foundation, will not exceed the limits recommended by the HI.

7.1.9.6 Casing Rings

Renewable casing wear rings heat treated to a hardness of at least 50 Brinell greater than the impeller or impeller wear rings, will be provided on medium and large pumps.

7.1.9.7 Pumping System Design

Where two or more pump systems of the same type or size are required, the pumps will be procured from the same manufacturer. Pumps will be selected and sequenced so that they normally operate within their allowable operating region in accordance with the HI Pump Standards. All centrifugal pumps will have a continuously rising curve. In no case will the required power at any point on the performance curve exceed the rated power of the motor or encroach on the service factor.

7.1.10 Storage Tanks

7.1.10.1 Material Selection and Tank Features

The storage tanks material will be determined based upon the characteristics of the liquid that is to be stored. Features that will be provided on tanks will include:

- Nameplates
- Access Ports (for large tanks)
- Vent lines and overflow
- Platforms
- Conservation valves and rupture discs

7.1.10.2 Access Ports

Each tank will have a way to enter the vessel for periodic inspection and cleaning. Ports will meet OSHA standards for size and function. Ports of at least 600 mm in diameter will be provided.

7.1.10.3 Vent Lines and Overflow

Atmospheric tanks will have vent lines provided with an insect screen and/or desiccant breather to protect tank contents. The vent line will run outside, or into a suitable ventilation system for exhausting fumes and moisture. Vent lines will be sized to prevent collapsing the tank during pump out or drainage activities. The overflow line will be routed to a drain or containment system, where the contents can be safely and efficiently handled.

7.1.10.4 Platforms

Platforms will be provided to access tank access ports inspection doors, top mounted relief valves, and other tank accessories. Platforms will be designed to meet OSHA safety standards.

7.1.11 Hoisting and Conveying

No hoisting or conveying will be provided for this project.

7.1.12 Piping

Plant piping includes yard piping, which may be entirely designed and specified outside of the mechanical discipline. Piping material will be compatible with the fluid transported within the pipe and for the environment in which the pipe is installed. Piping material for chemical feeding systems will be resistant to corrosive attacks from the specific chemical and selected to resist heat at acid dilution locations.

7.1.12.1 Piping Selection

The majority of the plant piping will be in SST 316 L with galvanized and epoxy painted carbon steel backing flanges. Bolting will be in SST 316. Gaskets will be NSF 61 certified thermoplastic for general service. Polyvinyl Chloride (PVC) and Chlorinated Polyvinyl Chloride (CPVC) piping will be used for chemical services, except for sulfuric acid which will be high grade SS. Polypropelene lined steel pipes will be used near the acid application locations to provide resistance to elevated temperatures due to acid dilution. Metal piping will be insulated to prevent condensation.

7.1.12.2 Seismic Design

Sway struts and braces will be provided to restrain piping seismic forces as required by the BC Building Code for “Post Disaster Buildings.”

7.1.13 General Valve Requirements

General service valves will generally be selected to comply with AWWA standards. Valves for use in chemical feeding equipment and piping systems will be in PVC, CPVC, or fluoropolymer-lined steel body. Except for the waste streams to sanitary sewer disposal, all valves will be specified to be NSF 61 certified.

Valves will be equipped with permanently installed electric or pneumatic operators when either of the following criteria applies:

- Valve operation is anticipated to be more frequent than once per month
- The valve might require rapid or instantaneous operation in response to some condition

Electric operators for modulating service will be selected with solid-state starters and built-in torque display and diagnostic modules.

7.2 Civil

7.2.1 Raw Water Transmission Main

7.2.1.1 Design Basis

Horizontal Alignment

- Length – Minimize the overall length of pipeline required (to minimize capital cost)
- Common alignment – Install the pipeline along the same alignment as for the access road, unless diverging will reduce installation costs
- Tree removal – Minimize impact on existing forested area as much as practical
- Buffer area – Leave a treed section of land between the Island Highway and the pipe alignment
- Rights-of-way (ROWs) – Minimize encroachment on the existing Ministry of Transportation and Infrastructure (MOTI) and Island Corridor Foundation (ICF) ROWs (for the Island Highway #19 and the E&N Railway)
- Riparian area – Minimize detrimental impact on the Englishman River riparian area

Vertical Alignment

- Minimum depth of cover – Must be sufficient to prevent frost and pipe damage from vehicle loading
- Maximum grade – Areas steeper than 8 percent require installation of a trench dam as required by CoP Engineering Standard W-1

Pipe Sizing

- Total design flow = 48 ML/d
- Maximum velocity = 2.0 m/s

Pipe Material

- Working pressure = 690 kPa
- Seismic – Joints must be fully restrained to provide for seismic reliability
- Material – Must be suitable for use with potable water (according to American Waterworks Association [AWWA] pipe material standards)

7.2.1.2 Preliminary Design

Horizontal Alignment

The proposed transmission main alignment is shown in Drawings C-W-001 and C-W-002 in Appendix A. The transmission main will generally follow the centre of the proposed access road (see Section 7.1.2) between the Island Highway (Highway 19) and the Esquimalt & Nanaimo Railway. The proposed transmission main alignment has received approval in principle from MOTI but must receive formal approval from MOTI and ICF during the next stage of design.

Vertical Alignment

The proposed transmission main profile is shown in Drawings C-W-001 and C-W-002 in Appendix A. The profile was selected using the following design rationale:

- The profile will rise continually from the raw water pump station to prevent sediment accumulation at low points

- In the section along the river (Station 0+000 to about 0+080), the crown of the pipe will be below natural grade to prevent damage to the pipe if the access road is damaged
- In the section between the MOTI and ICF ROWs, the main will be laid at approximately existing grade, and fill will be placed on top to get the required cover, eliminating the need for extensive shoring of the embankment fills during watermain installation

The minimum depth of cover for municipalities in the south coast region ranges from 0.9 m to 1.2 m. Given that the access road is subject to minimal vehicle traffic, a minimum depth of cover of 0.9 m for the transmission main is proposed. This depth of cover will also be sufficient for frost protection.

The limited geotechnical information near the highway bridge fill and piers indicates that bedrock is within 1.0 m of the existing ground surface in some locations; therefore, rock blasting will likely be required to install the transmission main. This requirement will be confirmed upon completion of the geotechnical report for this project.

Pipe Sizing

Based on the design flow of 48 ML/d, an inside diameter (ID) of 600 mm for the pipe is proposed. This pipe size will result in a maximum velocity of less than 2.0 m/s in the transmission main.

Pipe Material

CoP Bylaw No. 1261, "Subdivision Servicing Bylaw," permits use of ductile iron or polyvinyl chloride (PVC) pipe for watermains. However, the proposed pipe material for this application is 600-mm-diameter (nominal) carbon steel due to the improved reparability and reliability gained with steel pipe.

A working pressure of 690 kPa has been assumed for the pipe. The working pressure for the transmission main will be confirmed once the pump sizing has been finalized. Standard schedule carbon steel pipe has a sufficiently high pressure rating to suit the working pressure.

Valves

Buried isolation (line) valves will be required immediately downstream of the pump station and immediately upstream of the WTP. To minimize costs, the valves will be butterfly style. A 600-mm-diameter gate valve is significantly more expensive than a butterfly valve of the same size (typically on the order of 5 times the cost). No additional valves will be required on the transmission main.

7.2.2 Access Road (WTP Site to Intake)

7.2.2.1 Design Basis

Horizontal Alignment

- Access – Provide vehicle access to the intake pump station from the WTP
- Cut/fill balance – Minimize the total volumes of cut and fill required for construction (to minimize capital cost)
- Slope stability – Minimize detrimental impact on the existing banks of the Englishman River (slope stability to be reviewed as part of the geotechnical report)
- Tree removal – Minimize impact on existing forested area as much as practical
- Buffer area – Leave a treed section of land between the Island Highway and the intake access road

Vertical Alignment

- Maximum grade = 11 percent
- Elevation – Finished grade above the 200-year flood elevation, including 1.0-m freeboard

- Vertical clearance – Minimum clearance of 5.0 m from finished road grade to underside of railway and highway bridges (as stated in MOTI typical design guidelines)

Cross Section

- Design vehicle – The road must accommodate a rubber-tire crane for removing and installing the pumps
- Road structure – The road structure must support the design vehicle
- Road surface – The road surface must have minimal maintenance requirements
- Road drainage – The road cross section must be graded to shed water from its surface and prevent pooling of runoff from the hillside

7.2.2.2 Preliminary Design

Horizontal Alignment

The preliminary horizontal alignment of the access road is shown in Drawings C-W-001 and C-W-002 in Appendix A. The road crest is at the 200-year flood construction level (FCL) from Station 0+000 to 0+080. The alignment crosses underneath the Highway 19 bridge, goes east up an existing access road between Highway 19 and the E&N Railway, and then goes north across the E&N Railway to the WTP site, crossing through both the MOTI and ICF ROW. The proposed alignment has received approval in principle from MOTI but must receive formal approval from MOTI and ICF during the next stage of design. The road will be gated at the rail crossing.

Vertical Alignment

The profile of the preliminary vertical alignment of the access road is shown in Drawings C-W-001 and C-W-002 in Appendix A. The maximum grade will be less than 11 percent, which will allow the design vehicle (rubber-tire crane) to travel between the WTP and the pump station. The elevation gain between the intake and the WTP will be approximately 13 m.

The vertical clearance between the proposed road surface elevation and the underside of the highway will be more than 5 m, and clearance will not constrain access road placement.

Due to the need to have the road crest above the FCL and the need to reduce shoring requirements of the highway and rail embankments during watermain installation, the road will be primarily in fill. The estimated volume of fill required to construct the road (allowing 1 m of freeboard above the 200-year-flood elevation) is approximately 2,100 m^3.

Cross Section

The proposed road width is 5 m. The proposed road width will be sufficient for one-way traffic for the design vehicle. The road crossfall will slope toward the downhill side such that surface flow will run downhill toward the river.

The proposed road structure will be 75-mm-minus crushed gravel at least 300 mm thick, capped with a layer of 19-mm-minus crushed gravel at least 100 mm thick. At some locations the roadway will need to be over-excavated to provide for this minimum gravel thickness. The road structure will be confirmed in detailed design.

In locations where pooling could occur (low points on the road profile), culverts will be installed to convey runoff under the road and to the downhill side of the slope. We anticipate that two culverts (approximately 10 to 15 m long each) will be required. A ditch on the inside edge of the road will keep runoff from the hillside from flowing across the road. The ditch will cross the road at one of the culvert locations.

7.2.3 Transmission System

7.2.3.1 Design Basis

Demands

The upgrades were sized based on factored 2050 demands (projected 2050 water demand multiplied by a safety factor as discussed in Section 2.1). The required construction phasing for the demands is based on unfactored 2018 and 2035 demands.

Required Fireflows

The required fireflow, which is determined according to land use type, is summarized in Table 7-1. The fire storage required for each pressure zone is calculated according to the governing ICI land use, summarized in Table 7-2. CoP provided required fireflows (based on fire underwriter's survey) to be used to evaluate the transmission system in Parksville.[1] The required fireflow for NBP was developed through discussions with Koers & Associates[2] and verified with RDN staff.[3]

TABLE 7-1
Minimum Required Fireflows by Land Use Type

Land Use Type	Required Fireflow (L/s)	Duration (hr)	Storage Volume (ML)
Single Family Residential (CoP)	75	1.625	0.44
Multi-Family Residential	150	2	1.08
Comprehensive Development	90	1.85	0.60
Downtown Commercial	250	3.25	2.93
Resort/Recreational	250	3.25	2.93
Institutional	250	3.25	2.93
Industrial	200	2.5	1.80
Rural	75[a]	1.625	0.44
Single Family Residential (NBP)	60	1.4	0.30
Institutional, Commercial, Industrial (NBP)	150	2	1.08

Notes:
[a] Where fire hydrant protection is available.
NBP = Nanoose Bay Peninsula

[1] Email from Mike Squire, August 21, 2013.

[2] Email from Chis Downey (Koers & Associates Engineering Ltd), February 11, 2014.

[3] Email from Mike Donnelly, February 12, 2014.

TABLE 7-2
Governing Land Use and Fireflow Requirements by Pressure Zone

	Existing		Future 2050	
Pressure Zone	**Governing Land Use**	**Required Fireflow (L/s)**	**Governing Land Use**	**Required Fireflow (L/s)**
CoP Low Zone	Downtown Commercial	250	Downtown Commercial	250
CoP High Zone	Downtown Commercial	250	Downtown Commercial	250
NBP Madrona	Single Family Residential	60	Single Family Residential	60
NBP Nanoose	Marina	150	Mixed Use, Marina	150
NBP Andover	Golf Course	60	Golf Course	60
NBP Garry Oak	Oyster Farm	60	Oyster Farm	60
NBP West Bay	School, Community Hall, Grocery	150	School, Community Hall, Mixed Retail	150
NBP Fairwinds	Fairwinds Centre	150	Mixed Use, School	150
NBP Supply	Single Family Residential	60	Single Family Residential	60
NBP Arbutus	Single Family Residential	60	Mixed Use	150

System Pressure

Desired minimum pressures from the Master Municipal Construction Documents Municipal Infrastructure Design Guideline Manual are outlined in Table 7-3.

TABLE 7-3
Desired Minimum Pressures

Design Case Description	Desired Minimum Pressure (kPa/psi)
Peak hour demand	300/44
Fireflow plus maximum day demand	150/22

7.2.3.2 Required Upgrades

General

Upgrades to the transmission system will be required to convey water from the new WTP to customers in the CoP and RDN. These upgrades will include new and upsized watermains, new and upsized reservoirs, and new and upsized pump stations, as shown in Drawing C-130 in Appendix A.

Transmission Mains

Table 7-4 lists details on each transmission main upgrade.

TABLE 7-4
Watermain Upgrades

Task No.	Length (m)	Nominal Diameter (mm)	Location	Required For[a]	Phasing (year required)	Replacement/ New
W1	4,850	600	WTP to Springwood Reservoir #4 via Martindale Rd, Private property and the E&N ROW. New ROW required.	Supply redundancy, PH	2016	New
W2	1,110	400	WTP to industrial reservoirs via the E&N ROW and Top Bridge Park. New ROW required.	PH	2016	New
W4	460	400	NBP Supply Pump Station on Industrial Way to NW Bay Road via Island Highway East and an existing highway crossing.	PH	2018	New
W6	2,520	300	NW Bay Road to Anchor Way via private property, Harold Rd, Transtide Dr and Florence Dr. New ROW required.	PH	2035	New
W8	2,240	300	Schooner Cove Drive Loop water main	FF	2035	New
W11	160	250	High Zone Loop, Ackeman Rd to Stanhope Rd	FF	Under Construction in 2014	New
W12	220	350	ROW between Lodgepole Dr and Chestnut St	FF	2050	Replace
W13	240	400	Springwood booster station to Chestnut St	FF	2050	Replace

Notes:
FF = fire flow
PH = peak hour
ROW = right-of-way

Tasks W1 and W2 are essential to the operation of the water treatment plant and will be constructed with the plant. Task W1 is a transmission main connecting the water treatment plant and Springwood Reservoir (Reservoir #4) and is a second crossing of the Englishman River; the existing crossing is at a bridge at Highway 19A. This upgrade, to be done in 2016 with the water treatment plant construction, is required to provide adequate pressures in the west side of Parksville and to provide a redundant supply across the river. Task W2 is a transmission main connecting the water treatment plant to the CoP industrial reservoirs (Reservoir #5). It must be constructed with the water treatment plant to convey water to eastern Parksville and the RDN.

For the other tasks, the earliest phasing horizon is 2018. The demands in 2018 are 5% higher than the demands in 2013; therefore, the projects that are required in 2018 are effectively required immediately. However, not all of the 2018 projects are required in order for the water treatment plant to function; that is, if they are not constructed, the water system will continue to perform as it does currently.

Reservoir Upgrades

Reservoir upgrades will be needed to provide adequate balancing, fire, and emergency storage. Storage requirements for factored 2050 high-growth demands for each service area are shown in Table 7-5. The balancing storage requirement is calculated as 25 percent of the zone MDD. The fire storage required for each pressure zone is calculated according to the governing land use. The emergency storage is calculated as 25 percent of the sum of the balancing storage and fire storage requirements.

The Parksville High Zone fireflow requirement is supplied from the Low Zone using a fire pump. The Fairwinds, Madrona, Andover, West Bay, and Nanoose zones are supplied with fireflows from the Fairwinds Reservoirs. The Arbutus Zone is supplied with fireflows from the Fairwinds Reservoirs using a fire pump.

TABLE 7-5
Reservoir Upgrades for Factored 2050 High-Growth Demands by Fireflow Service Area

Reservoir	Existing Volume (ML)	Required Storage (ML)				Deficiency (ML)
		Balancing	Fire	Emergency	Total	
CoP Low Zone & CoP High Zone						
Industrial 3	0.7	8.0	2.9	2.7	13.6	4.1
Springwood 4	4.6					
Reservoir 5	4.3					
Total	9.5					
NBP Fairwinds, NBP Madrona, NBP Andover, NBP West Bay, NBP Nanoose, NBP Arbutus						
Fairwinds 1	0.9	3.0	1.1	1.0	5.1	1.0
Fairwinds 2	0.9					
Beachcomber	Not in service					
Eagle Heights	0.7					
Madrona	0.5					
Dolphin	0.5					
Arbutus	0.6					
Total	4.1					

Note:
CoP = City of Parksville
NBP = Nanoose Bay Peninsula

Considering the deficiencies in reservoir capacity shown in Table 7-5, the reservoir upgrades shown in Table 7-6 are recommended. The upgrade planned for the Fairwinds reservoirs (Task R2) in 2018 is primarily driven by fireflow requirements.

None of the reservoir upgrades must be constructed with the water treatment plant and are therefore not included in the treatment plant construction project. However, the future Springwood Reservoir upgrade will be considered in the design of the W1 transmission main.

TABLE 7-6
Reservoir Upgrades

Task No.	Task Name	Serves Zones	Required For	Volume (ML)	Phasing (year required)
R1	Springwood Reservoir Upgrade	CoP Low Zone, CoP High Zone	Balancing, fire, and emergency storage	4.1	2035
R2	Fairwinds Reservoir Upgrade	Fairwinds, Madrona, Nanoose, West Bay, Andover, Garry Oak, Arbutus (via fire pump)	Balancing, fire, and emergency storage	1.0	2018

Pump Station Upgrades

The recommended pump station upgrades are summarized in Table 7-7.

TABLE 7-7
Pump Station Upgrades

Task No.	Task Name	Installed Power (kW)	Phasing (year required)
P0	Pump station in WTP (High Lift Pump Station)	See Section 6.8	2016–2035
P1	NBP Supply Pump Station	270	2018
P3	Springwood booster station fire pump upgrade	160	2018
P4	Arbutus fire pump upgrade	100	2050
P5	Decommission Existing Craig Bay pump station	N/A	2035

Notes:
ASR = aquifer storage recovery
NPB = Nanoose Bay Peninsula

Task P0 is the treated water booster pump station in the WTP that pumps from the clearwell to the Parksville 74-m Low Zone via the W1 and W2 transmission mains; this pump station is discussed in Section 6.10.

Task P1 and the accompanying Task P5 is the decommissioning of the existing Craig Bay Pump Station and the construction of a new pump station (and associated watermain Task W4) close to the existing station at the eastern end of Industrial Way. KWL has been informed that the Northwest Bay Road supply main can operate at a hydraulic grade of 160 m geodetic datum[4], and therefore a single pump station can deliver the required flow from the proposed NBP supply pump station site to the Fairwinds Reservoirs.

The existing Craig Bay Pump Station only has a single pump, and is a critical supply source for the NBP (roughly 60% of the supply capacity). Given the station's critical role, it is recommended that it be replaced with a duplex (or triplex) station with a redundant pump.

Two pump station upgrades are also required to provide adequate fire protection to the CoP High Zone (Task P3) and Arbutus Zone (Task P4). The CoP High Zone (Springwood) fire pump upgrade to be constructed in 2018 is required to address an existing fireflow deficiency. The Arbutus Zone fire pump upgrade is listed as being required in 2050 but will be triggered by development of the Mixed Use lot in the Arbutus Zone.

Task P0 will be constructed along with the water treatment plant. All other pump station upgrades are not essential to operation of the water treatment plant and their construction should be phased accordingly.

7.2.4 Site Servicing

7.2.4.1 Site Grading and Elevation

The proposed site slopes gently from the south to the north. The grades generally range from an elevation of approximately 29.5 m to 27.5 m. One exception is the northwest corner of the site, which encroaches on the gravel pit excavation. Elevations in this corner are as low as 22.5 m, and will be filled as part of the site grading. The approximate volume of fill required for this portion of the site is 2,000 m^3.

7.2.4.2 Lanes and Parking Areas

Lanes

The standard width for the two-way lanes through the site is 7.5 m. All lanes will be designed for passage of a long semi-trailer with a minimum turning radius of 15 m. The lanes will be crowned or cross-falled as appropriate for overland flow of stormwater.

All lanes and asphalt surfaces in the works yard will be surfaced with gravel, chip seal or asphalt. Since the site is relatively flat, we expect that linear grades can be maintained at a maximum of 3 percent.

[4] Mr. Chris Downey, P.Eng., Koers and Associates, personal communication May 28, 2014.

Roads in the eastern half of the site (Herring Gull Way side) will have non-mountable concrete curbs with gutters.

Parking Dimensions

Parking dimensions will be according to CoP standards.

The parking areas will be surfaced with 65 mm of asphalt, 100 mm of 19-mm-minus crushed gravel base, and 250 mm of sub-base. We anticipate that parking areas will be kept at grades of less than 3 percent.

7.2.4.3 Stormwater

Stormwater management will be undertaken using best management practices (BMPs) for capture, infiltration and discharge of runoff. The following sections describe the design criteria that will be used, as well as the proposed stormwater management features.

Stormwater Bylaw

The CoP's drainage design criteria are quoted below:

- Minor and Major Systems
  - The minor system shall consist of pipes and ditches which convey flows of a 10-year return frequency
  - The major system shall consist of surface flood paths, including roadways and watercourses, which convey flows of a 100-year return frequency
- Developments are required to provide detention to pre-development levels.

Stormwater Connection

Minor swales exist on both sides of Herring Gull Way. The diameter of the two existing culverts under the site access driveways are 200 mm and 300 mm, respectively. Direct runoff from the proposed impervious surfaces from the site would overwhelm the capacity of the existing swales and culverts on Herring Gull Way. Instead of upgrading downstream conveyance capacity, infiltrating stormwater is proposed, as discussed below.

Soil Conditions

The soils for the site are described in the pre-design geotechnical investigation prepared by Golder Associates, which drilled three boreholes on the site. The upper soil layer consists of stratified gravelly sand to sand and gravel, to a depth of 10 m or greater. At two of the boreholes, the depth to groundwater was 10.0 m and 16.7 m below ground surface, respectively. For most rainfall events, these soil conditions and groundwater table levels are suitable for stormwater infiltration.

Site Runoff

The proposed site will have the following surface area characteristics:

Surface Type	West Portion of Site (m^2)*	East Portion of Site (m^2)*
Building roof	1,780	2,690
Asphalt / concrete	470	2,930
Chip seal pavement	8,720	0
Grass / landscape	2,570	3,280

*areas to be confirmed during final site design

The eastern portion of the site is open to public access and generally consists of parking, landscaped areas, and the WTP. The western portion of the site is gated, and includes the public works yard, shop, vehicle wash, refueling area, salt and brine sheds, and miscellaneous storage areas. The surface areas listed above exclude areas outside the developed portions but still within the property lines. Significant runoff volume is not expected from these areas due to the soil conditions which are expected to have a high infiltration rate.

In addition to stormwater runoff, there will be flow to the stormwater system of approximately 0.6 L/s from the WTP sand separators. Additionally, an overflow from the clearwell will be provided to the storm drain system for the full treatment capacity of 555 L/s.

Drainage for the truck wash/fill station and fueling areas will be connected to the storm sewer system via oil/grit separators.

Stormwater Management

The stormwater management measures for the site will be:

- Stormwater runoff for frequently occurring events (up to the 5-year return period) will be managed on site through stormwater BMPs (capture, infiltration, and detention). Due to the relatively high infiltration capacity of the underlying soils, it is expected that these criteria can be met with BMPs located within the proposed green spaces.
- Stormwater runoff for extreme events (greater than 5-year return period) will be conveyed to the CoP-owned gravel pit to the west of the treatment plant site for in-ground infiltration. A new point of discharge for the site is not proposed.

Minor Event BMPs

The minor event BMPs will include the technologies discussed below.

Detention and Infiltration Ponds

Detention and infiltration ponds will primarily capture the runoff from the laneways and parking surfaces. Approximately 760 m^2 of sunken lawn will detain stormwater and allow for infiltration during rain events. During extreme events, this dry detention pond will overflow to the storm drain system and gravel pit.

Major Event Stormwater System

For events larger than the 5-year return event, a storm drain system sized to convey a 100-year return event will convey overflows from the minor systems to an infiltration facility in a former gravel pit west of the site. This storm drain will also be sized to convey the clearwell overflow to the infiltration facility. The ability of a facility at the location to infiltrate the 555 L/s clearwell overflow and 100-year event will be confirmed through an infiltration test as directed by a hydrogeologist. Surface storage/detention may be required. An overland flow route from the gravel pit does not currently exist, and the infiltration facility must not overflow and erode a new overland flow route down to the Englishman River.

7.2.4.4 Sanitary Sewer

Connection to Municipal System

The site's wastewater sources will include:

- Water treatment plant (lab, washrooms, utility room, process area)
- Existing building
- Vehicle wash area
- Fueling area

The sanitary sewer service will connect to the existing 200-mm-diameter PVC sanitary sewer main on Herring Gull Way. The Herring Gull Way sewer minimum grade is 0.58 percent, and the capacity is 30 L/s. The Herring Gull Way 200-mm-diameter sewer connects to the 375-mm-diameter trunk sewer on Industrial Way.

The invert elevation of this sewer is 25.5 m at the northeast corner of the site, and 25.9 m at the middle of the lot frontage (location of existing engineering/stores building connection). The existing sanitary sewer on Herring Gull Way is low enough to service the ground-floor elevations of the proposed facilities by gravity (pumping will not be required) except for the WET tank. We propose that the existing service to the engineering/stores building remain for that facility.

Design Flows and Sizing

Sizing of the sanitary sewers will be confirmed prior to the detailed design based on the methodology outlined in the 2012 BC plumbing code, once a final fixture unit count has been completed. The estimated required service sizes and estimated peak flows for each of the buildings are shown in Table 7-8.

TABLE 7-8
Estimated Sanitary Sewer Service Sizes and Flows

Building	Estimated # of Fixture Units	Sewer Diameter (mm)	Flow (L/S)	Notes
Treatment plant (lab)	2	50	< 5	Assume 1 sink
Treatment plant (process area)	N/A	150	5	0.4 ML/d to an equalization basin, which will minimize the hydraulic impact on the sanitary system
Treatment plant (washrooms)	12	100	< 5	Two washrooms
Treatment plant (utility room)	1	100	< 5	Assume 1 sink
Engineering/stores	N/A	150	N/A	The existing sanitary service to this building will be maintained
Shop	12	100	< 5	Assume 2 washrooms
Fueling area	N/A	100	< 5	
Vehicle wash area	3	100	< 5	Assume equivalent to industrial sink

Approximately 30 sanitary sewer fixture units will be needed for the new sanitary sewer service. For this number of fixture units, the required sanitary sewer service size is 100 mm. However, considering the additional discharge of 5 L/s from the treatment plant process, the sanitary sewer service size should be 150 mm, in addition to the existing 150-mm service to the engineering/stores building, which will remain.

Downstream Capacity

The estimated peak sanitary sewer flow from the site will be approximately 10 L/s. Information provided by the CoP indicates that the Official Community Plan (OCP) development scenario requires at least 16 L/s of excess capacity. Therefore, downstream upgrades to the sanitary sewer system to accommodate flows from this development are not anticipated.

7.2.4.5 Water

Potable Water

Potable water to the site will be serviced from the existing 200-mm-diameter PVC main on Herring Gull Way. Sizing of the onsite watermains and services will be confirmed prior to the detailed design based on the methodology outlined in the 2012 BC plumbing code, once the fixture unit count has been finalized. The estimated required service sizes and peak flows for each of the buildings are shown in Table 7-9.

TABLE 7-9
Estimated Water Service Sizes and Flows

Building	Fixtures or Devices	Number	Fixture Units	Water Service Diameter (mm)	Flow (L/s)
Treatment plant	Lab	1	TBD	TBD	
	Washrooms	2	2@6 = 12	25	<5
	Utility room (hot water tank)	1	TBD	TBD	
Engineering/store[a]	TBD			38	< 5
Shop	Washrooms	2	2 @ 6= 12	25	< 5
	Hose bibs	3			
Vehicle wash area	Industrial sink	1	3	25	< 5
	Hose bibs	2	2 @ 2.5 = 5		
Truck fill station	Stand Pipe	1	N/A	50 mm	N/A

Notes
[a]The building will be connected to the new service; existing meter to be removed
TBD = to be determined

The water pressure in the existing main on Herring Gull Way during peak hour demand is approximately 410 kPa (60 psi). The potable water service to the site will be 100 mm in diameter, with smaller branches to each of the buildings.

Fire Protection

Fire protection water will service fire hydrants on the sites. The fire protection mains will be serviced from a separate connection to the existing 200-mm-diameter PVC main on Herring Gull Way. An analysis of the existing water system was completed. This indicates that 170 L/s of fireflow is available to the site from the mains on Herring Gull Way. As outlined in *TM#4B: Distribution System Upgrades – Water Modelling* in Appendix H, for industrial land-uses, the minimum required flow is 200 L/s. We recommend that the building designers complete a fire underwriters survey (FUS) calculation for each of the site buildings to determine the fireflow requirement.

The two existing fire hydrants along the lot frontage will remain. To maintain a maximum 75-m hydrant spacing, two onsite hydrants will be provided. The locations and requirement for fire hydrants is to be discussed with the fire marshal during detailed design.

7.2.4.6 Power, Telephone, and Data

Incoming Hydro service will be run in underground conduit from a new termination pole installed at the site entrance on Herring Gull Way.

Additional conduits will be provided for telephone and data connections. Exact routing and demarcation points will be determined during detailed design.

7.2.4.7 Natural Gas

Natural gas to the site will be serviced from the existing gas main on the east side of Herring Gull Way. The size of the gas service will be based on the demand, and the final location of the connection point and meter will be confirmed through coordination with the CoP, architect, and Fortis BC.

7.3 Geotechnical

A geotechnical subsurface investigation of the areas of the intake structure and pump station, new shop building, and WTP was carried out in December 2013. Details of the investigation are contained in *Preliminary Design Geotechnical Repor*t (Golder, 2014) contained in Appendix K. In the investigation, four boreholes were advanced through the subsurface material to depths from 9.8 to 31.1 m below ground surface (bgs).

The proposed intake structure and raw water pump station will be constructed on a topographic bench located approximately 3 m above the elevation of the adjacent Englishman River. Near the proposed intake structure, one hand-auger borehole (HA13-05) was advanced to approximately 0.4 m bgs through the subsurface along the river bank.

The report described the stratigraphic units underlying the lower bench as follows (in order of increasing depth bgs):

- Topsoil – The topsoil encountered was described as dark grey, loose to compact, non-cohesive, moist, and containing organics and woody debris
- Alluvial deposits – Alluvial deposits were encountered underlying the topsoil. The alluvial material encountered was described as a mixture of soil and cobbles/boulders and was up to 5.9 m in thickness.
- Glacial till – Till was encountered underlying the alluvial deposit. The till was described as a dark grey, compact to very dense, moist silty sand to a silty sand and gravel.

The proposed WTP and new shop building will be within the CoP's Public Works Yard. The report described the following stratigraphic units (in order of increasing depth below ground surface):

- Stratified gravelly sand – Deposits of stratified gravelly sand to sand and gravel interpreted to be part of the Capilano Sediments deposit were encountered at depths up to 18.9 m bgs
- Glacial marine clayey silt – The material encountered was described as dark grey and varved, with black, clayey silt; consistency varied with depth from soft to very stiff
- Glacial till – Glacial till interpreted to be part of the Vashon Drift deposit was encountered underlying the glacio-marine silt from approximately 21.3 m bgs to the maximum depth of investigation, 31.1 m bgs.

As of the time Golder prepared *Preliminary Design Geotechnical Report*, they had not been provided with anticipated foundation layouts or loads for the intake and raw water pump station, or for the WTP and new shop building. However, the gravel and sand (alluvial) deposits encountered in the area of the proposed intake and raw water pump station are generally considered to be suitable foundation materials for structures such as those proposed. Considering the available information, a preliminary design allowable bearing pressure of 150 kPa should be suitable. Foundation dimensions and depths will be required to determine the final design bearing pressures for the site.

A site-specific seismic hazard calculation was obtained from the Natural Resources Canada (NRC) for firm ground conditions. The calculation was performed in accordance with 2010 seismic hazard maps of Canada using information on the site's location relative to inferred seismic sources and attenuation relationships. Considering the SPT blow counts, available groundwater information, and soil plasticity data, the soils encountered should not be subject to liquefaction under the design earthquake loading. However, the site investigation gave only preliminary information on groundwater levels; additional monitoring will be needed to confirm.

Supplemental geotechnical subsurface investigations are recommended once the arrangement of facilities is finalized. The recommended additional geotechnical investigation will assess subsurface condition variability across the site and confirm the geotechnical interpretations presented in *Preliminary Design Geotechnical Report*. It is anticipated that the supplemental investigations will include further assessment of groundwater levels, possible additional subsurface investigation within the footprint of the proposed treatment plant, and an assessment of the raw water conveyance lines once the layout has been finalized. This additional information will be used to provide design bearing pressures, evaluate potential settlement of the structures, confirm preliminary liquefaction susceptibility assessment findings, and provide detailed geotechnical recommendations to meet the project requirements based on the proposed design.

7.4 Structural

7.4.1 Water Treatment Plant

The WTP structure will consist of one single level building with an elevated catwalk to access the top of the chemical storage tanks.

Reinforced concrete footings and slab-on-grade is proposed for the treatment plant area. Equipment will be installed on concrete pads raised above ground level. Below-grade structures such as tanks, pipe chases, trenches, and sumps will be included in the design, and construction joints will contain PVC waterstops to eliminate leakage.

The WTP superstructure will have a steel frame with an exterior architectural cladding system. The metal access platforms at the mezzanine level will be either aluminum or steel grating supported on CMU walls or structural steel. A prefabricated zee girts or roof beams with steel deck will be used support the roof assembly.

Skylights will allow removal and replacement of equipment inside, and will provide some natural light.

7.4.2 Intake and Raw Water Pump Station

The cast-in-place-concrete intake structure will be located on the north bank of the Englishman River at an elevation that allows water to flow freely through sloped metal intake screens. It will be divided into two bays so that one can be taken out of service for maintenance.

The pump station will be set back and located further north up the bank to suit layout provided above the 200-year flood protection level. Reinforced concrete footings and slab-on-grade will be used for the ground floor. The superstructure walls will be composed of reinforced concrete masonry units or cast-in-place concrete. The walls will be coated with an anti-graffiti product. Skylights in the roof will allow removal and replacement of equipment inside. The pump station structure will be designed to accommodate addition of equipment and piping in the future.

A set of stairs will provide easy access between the intake structure and pump station.

7.4.3 Design Approach and Methodology

A rational design method will be used, incorporating all applicable aspects of structural analysis and design. Groundwater presence, buoyancy, in-situ and engineered fill soil conditions, environmental loads, live loads, equipment and operating loads, stability requirements, serviceability, and safety requirements will all be considered in the design process. Project specifications and drawings will define the requirements for safe and serviceable structures.

The objective-based model code, National Building Code of Canada 2010, identifies public water treatment and storage facilities and pumping stations as post-disaster facilities. The code commentary describes the performance objective for post-disaster buildings as “immediate occupancy” from an earthquake (seismic) point of view. Structure, contents, and mechanical, electrical, plumbing, and other systems necessary for normal operation are expected to remain operational after the design earthquake.

7.4.4 Codes and Standards

Structural design will, in general, be guided by National Building Code of Canada 2010. Local requirements will be based on the current British Columbia Building Code (2012).

Codes to be referenced in the design will include:

- National Building Code of Canada 2010, and referenced standards therein
- British Columbia Building Code 2012
- Canadian Standards Association (CSA) S16-09 Design of Steel Structures
- CSA A23.1-09 Concrete Materials and Methods of Concrete Construction
- CSA-A23.3-04 Design of Concrete Structures
- The Workplace Safety and Health Act
- National Sanitation Foundation Standard 61
- Occupational Health and Safety Act and Regulations for Construction Projects
- CSA B167, Safety Standard for Maintenance and Inspection of Overhead Cranes, Gantry Cranes, Monorails, Hoists, and Trolleys
- ACI 350M-06 Code Requirements for Environmental Engineering Concrete Structures and Commentary
- ACI 350.3-06 Seismic Design of Liquid Containing Concrete Structures and Commentary
- ACI 350.4R-04 Design Considerations for Environmental Engineering Concrete Structures

7.4.5 Design Parameters

Table 7-10 shows the structural design parameters (climatic and seismic information, live loads, and live load deflection criteria).

TABLE 7-10
Design Parameters

Climatic and Seismic Information: BCB 2012 for Parksville, BC	
Design temperature (°C)	–6 to +26
One-day rain (mm)	1/50 to 91
Snow load (kPa)	Ss = 2.4
	Sr = 0.4
Hourly wind pressures (kPa)	1/10 to 0.39
	1/50 to 0.5
Seismic data	Sa(0.2)= 0.86
	Sa(0.5)= 0.61
	Sa(1.0)= 0.32
	Sa(2.0)= 0.17
	PGA = 0.42
Live Loads	

TABLE 7-10
Design Parameters

Minimum Uniform Live Loads	
General personnel areas, stairs and walkways	4.8 kN/m^2
Minimum roof and ceiling load allowance	1.0 kN/m^2
Floor loading with actual Equipment weight, but not less than	14.4 kN/m^2
Floor loading, other rooms	5.0 kPa minimum
Equipment loads	Based on data supplied by the equipment manufacturers and will include self-weight (and any added items such as piping, liquids, curbs), operating loads, dynamic loads, and rotating mass.
Minimum Concentrated Live Loads	
General personnel areas, stairs, and walkways	9.0 kN
Minimum roof access load	1.3 kN
Equipment rooms	10.0 kN
Live Load Deflection Criteria	
Floor plates and grating	L/240 or 6 mm maximum
Platforms and walkways	L/240
Roof structures	L/360
Floor structures	L/360

Note:
Concentrated live loads are applied over an area of 750 mm x 750 mm located where they will cause maximum effects.

7.5 Architectural

7.5.1 Building Code Review

Table 7-11 shows the program areas that will be used for BC Building Code analysis.

TABLE 7-11
EWRS Program Areas

Water Treatment Plant Building		**Qty**	**Total Area (m^2)**	**Notes**
1	Foyer (Entry and vestibule)	1	34	Principle entry and vestibule
2	Washrooms (M/W)	2	8	Adjacent to foyer
3	Process Area	1	674	Contains membranes, electrical equipment, sand separators and UV
4	Control room	1	21	Viewable from exterior and overlooks process area
5	Chemical room	1	247	Adjacent to process area, with upper walkway
6	High Lift Pumping Station Room	1	157	Adjacent to process area; also contains blowers/compressors and backwash pumps
7	Lab	1	33	Adjacent to process area

TABLE 7-11
EWRS Program Areas

Water Treatment Plant Building		Qty	Total Area (m^2)	Notes
8	Server Room	1	12	Adjacent to lab
9	Utility Room	1	8	Adjacent to lab and server room
Total Area (m^2)			**1204**	

Raw Water Pump Station		Qty	Total Area (m^2)	Notes
1	Main pump room	1	124	Single space
Total Area (m^2)			**124**	

The following preliminary comments from the building code review are provided for consideration (all references are to Part 3 of Appendix B of the National Building Code of Canada 2010 unless otherwise noted):

- Fire department access route – A fire department access route will be required in accordance with Articles 3.2.5.4 to 3.2.5.6.
- Spatial separation and exposure protection – The area of unprotected openings may be limited, subject to available limiting distances for the facades of the project. Specific fire-resistance ratings may be required for exterior wall assemblies (Subsection 3.2.3).
- Classification – The project will be constructed as one major occupancy (Group F3 [process]), with a building area (footprint) of approximately 1,204 m^2 and a building height of one storey. Subsection 3.2.2 permits combustible or noncombustible construction. If unsprinklered, a roof assembly of combustible construction would require a 45-minute fire-resistance rating.
- Exits from process area – exterior exit doors and interior egress doors must meet the maximum 30-m travel distance interpretation and remoteness separation required for this area.
- Fire alarm system – In accordance with Sentence 3.2.4.1.(4), the project does not need a fire alarm system based on occupant load.
- Emergency lighting – Emergency lighting is required in accordance with Article 3.2.7.3.
- Exit signs – Based on an occupant load of not more than 150 and a one-storey building height, exit signs are not required (Sentence 3.4.5.1).

7.6 Landscape Architecture

The WTP site layout (Drawing L-002 in Appendix A) shows the landscaping for the new WTP and existing works yard.

7.6.1 Location of Existing Structures and Trees to Remain

The existing building at the northeast corner of the site will remain. The shop area in this building will likely be altered since a new shop building is part of the development.

Existing trees fronting the existing building will, for the most part, remain. A location and grade survey of these existing trees is needed.

Existing trees along the south property boundaries should be surveyed so it can be determined which will remain and which will be replaced.

7.6.2 Location of New Structures, Lanes, and Parking

New structures will include a WTP building and a shop building. Other features will include relocated salt and brine areas, space for truck fueling and washing, general yard storage space, access, and parking.

The WTP building will be southwest of the existing building. Its long access will be perpendicular to the south property line. A covered sidewalk and pedestrian gate will separate the existing building from the new WTP building. A covered loading bay will be located on the west side of the WTP building.

Vehicle access will be provided by two driveways off Herring Gull Way. The north driveway is gated, and will be for staff vehicles only. The south driveway will provide access to the main parking lot and a gated access for staff (south of the parking lot). A loop driveway will provide access around the works yard. The loop driveway will connect to both driveways to Herring Gull Way; access to that road may be required during emergencies.

The existing security fencing will be adjusted to delineate the public area from the works yard. This will provide a secure area for the works yard functions, while allowing the public courtyard to be free of security fencing.

Vehicle parking will be provided for both the public and staff. The main parking area, south of the WTP building, will have 36 full-size stalls and two disabled parking stalls. A secondary visitor parking area will be provided with 14 stalls for smaller vehicles on the north side of the south driveway. If visitors park on the courtyard side, they will not need to cross the access road to get to the WTP building. At the northeast corner of the site, there are approximately six parking stalls on the south side of the north access, which could serve as staff parking.

No formal bus parking will be provided; however, buses will be able to park along the north driveway, allowing visitors to get to the site without crossing the access road. Buses will need to enter the works yard to turn around.

Space will be provided for an electrical transformer, diesel generator, and fueling and washing stations in the works yard. The new shop building will be centrally located, with road access on all sides.

7.6.3 Trail Connections and Trailheads

There are public trail systems in Top Bridge Park to the west of the site and on the south side of the Englishman River. A “rails to trails” public trail may also be constructed along the E&N Railway right-of-way to the west of the site in the future. At this time however, no trail connections between the public works yard site and adjacent regional trail systems are planned.

7.7 Electrical

7.7.1 Primary Power Source

Given the size of the load of the WTP, a new 600-V service will be provided to the site. BC Hydro has an existing overhead 25-kV line on Herring Gull Way, and a new tap and termination pole will be installed near the entrance to the works yard. The primary cables will be run down the pole and will be fed underground to a new padmount transformer north of the treatment building. The transformer will be customer-owned and -installed. BC Hydro will provide the primary connection and revenue metering. The exact scope will be defined during detailed design.

The transformer will be a liquid-filled padmount type. Preliminarily sized at 2,500 kVA, it will step down the voltage from 25 kV to 600 V. This capacity will suffice up to a 24 ML/d production capacity of the water treatment plant. For Phase 2 (48 ML/d) a second transformer would be added. The outdoor switchgear will have the amp rating for Phase 2 (48 ML/d) and include space for expansion.

The transformer will be grounded through a resistor to provide a high resistance grounding system. The fault current will be limited to 5 A. This will help protect personnel and equipment if a ground fault occurs.

Once the new electrical service has been installed and commissioned, a new feed to the existing building and new shop building will be provided, and the existing 120/208-V service will be decommissioned and removed.

7.7.2 Standby Power

A 1.0-MW diesel-engine-driven generator with a sound-attenuated, weatherproof enclosure will be provided for backup power. The generator will provide enough power for one raw water pump and one high lift pump, plus ancillary loads, which will satisfy a nominal flow of 16 MLD.

The generator will be supplied by a sub-base mounted fuel tank, sized for 10,000 liters of diesel fuel storage. This will provide up to 25 hours run time at full load (generator set fuel consumption of 400 L/hour).

The generator will be connected to the main distribution switchgear through an automatic transfer switch that is integral to the switchgear lineup.

7.7.3 Power Distribution

A 600-V outdoor switchgear will distribute power to the WTP, and the RWPS. The new shop building will be sub-fed from the MCC in the WTP. The switchgear will include draw-out-type air-insulated circuit breakers with solid state trip units. The switchgear will include distribution class lightning arrestors.

To help mitigate arc flash hazards when energized work may be required, the 600-V switchgear will have a maintenance switch to reduce the instantaneous trip-setting of each breaker. A remote control panel for circuit breaker operation will also be provided so that the switchgear or downstream motor control centres (MCCs) may be safely de-energized (away from the front of the switchgear).

Each 600-V MCC will distribute power to the field loads. Each MCC will include customer power metering for monitoring consumption at individual facilities, and each MCC will also include a surge protection device (SPD).

All loads requiring a motor starter (including VFDs) will be included in the MCC line-up, whereas loads only requiring circuit breakers will be fed from dedicated 600-V distribution panels mounted in the electrical room.

All VFDs will be specified with input and output line reactors, but the large number of plant loads driven by VFDs may necessitate further harmonic mitigation, perhaps including specifying 18 pulse drives or active harmonic filters on each MCC bus. This will be further investigated during detailed design.

A dedicated MCC in the RWPS will be fed by underground cables in the water transmission main alignment. Conduits for communications (fibre optic cable) will be included.

The electrical equipment layout has been designed to provide space for future doubling of plant capacity. In addition, the layout will allow redundancy when capacity is added, as it allows for creation of double-ended equipment (switchgear, MCCs).

7.7.4 Motors

All motors will be specified to be inverter duty rated and to meet the premium efficiency standards given in NEMA MG-1.

Motors will be specified to be no louder than 82 dbA when operating at full load. If this cannot be achieved, vendors will be asked to provide sound hoods.

7.7.5 Lighting

The treatment plant will be designed to allow natural light into the building. Artificial lighting will supplement where necessary.

Light fixtures will generally be wall-mounted no higher than 3 m above finished floor. Ceiling-mounted light fixtures will only be provided in areas with drop ceilings (control room, lab, washrooms, server room, utility room, foyer).

Lighting will be provided along walkways (routes of egress) and platforms. No lights will be located over equipment.

All entrances on the outside of the building will be illuminated with LED wallpacks controlled by a built-in photocell. LED floodlights will also be provided around the perimeter of the building.

General roadway lighting on the plant site will be provided by exterior pole-mounted light fixtures. Because of their excellent light distribution, high efficiency, and low maintenance, LED fixtures will be specified. They will be full cut-off type, orientated so that no light is directed past the property line.

7.7.6 Security

Proximity sensors on all doors and outside hatches will be installed to prevent unauthorized access. Illegal entry alarms will be sent to the supervisory control and data acquisition (SCADA) system.

A closed-circuit television (CCTV) camera will be installed on a pole to monitor the intake structure and the pumping station. It will include infrared capability to detect unauthorized access at night or in low light conditions. A switchable flood light will also be mounted on the pole. The video signal will be sent to the SCADA system through fibre optic cable.

Entrance doors will include card readers for controlling access.

7.8 Instrumentation and Controls

7.8.1 General Description

This section describes the design basis for the instrumentation and controls (I&C) system and presents the following information:

- Numbering system (equipment, valves, and instruments)
- Control system overview
- SCADA system design criteria
- Instrumentation design criteria

7.8.2 Numbering System

The plant equipment and instrument tag numbering system provided in Table 7-12 will be followed for equipment, valves, instruments, panels, programmable logic controllers (PLCs), and MCCs.

To keep the tag numbers as brief as possible, dashes are not used except where needed to distinguish between two fields, for example, between the process fluid abbreviation and equipment abbreviation in the equipment tag number.

TABLE 7-12
Tag Numbering System

Tag Number	Tag Number Elements	Description
Process Equipment (Equipment/Valve/Gate/Inline Flow Elements)		
65PMP32101	65	Building/area identification number
	PMP	Equipment, valve, or gate abbreviation
	32101	Sequential number
Non-Process Equipment (Electrical Equipment, HVAC Equipment, etc.)		
65PMP32101	65	Building/area identification number
	MCC	Equipment, valve, or gate abbreviation
	01	Sequential number

TABLE 7-12
Tag Numbering System

Tag Number	Tag Number Elements	Description
Instruments		
65FIT32101	65	Building/area identification
	FIT	Instrument abbreviation according to ISA standard
	321	Loop tag number differentiator (3 digits)
	01	Sequential number (2 digits)
	A	Optional suffix letter for multiple instruments
Loops		
6532101	65	Building/area identification
	321	Loop tag number differentiator (3 digits)
	01	Sequential number (2 digits)
PLC IO		
65 FIT 32101_FI	65	Building/area identification
	FIT	Instrument abbreviation according to ISA standard
	321	Loop tag number differentiator (3 digits)
	01	Sequential number
Control Panels		
65CP01	CP	Control panel abbreviation
	65	Building/area identification
	01	Sequential number
PLCs		
65PLC01	PLC	PLC abbreviation
	65	Building/area identification
	01	Sequential number

Notes:
IO = input/output
PLC = programmable logic controller

7.8.3 Control System Overview Description

The I&C system will include the necessary process monitoring, manual control functions, and automatic control functions to continuously meet the plant production and performance requirements. The I&C system will process alarms, archive data, and generate reports, as well as provide control, trending, and monitoring. It will consist of:

- Field-mounted instruments
- Local equipment control panels
- PLCs
- Communication networks, including network interface panels
- Plant-wide SCADA system

Primary plant operations will be through the distributed plant-wide SCADA system.

7.8.4 SCADA System Design Criteria

7.8.4.1 Control System Philosophy

All facility controls will allow both automatic and manual control of the equipment and processes (for equipment and processes where there is automatic control logic) from SCADA. If there is no automatic control logic, then the control will be manual only from the SCADA HMIs and local panels. Process control and alarm set points will be adjustable from the SCADA graphic displays. Manual backup will be provided for all facility equipment and processes.

7.8.4.2 SCADA Controls

When the local control station selector switch is set to REMOTE, the equipment will be provided with two control modes that are selectable from the SCADA graphic display: MANUAL and AUTOMATIC. In MANUAL, the equipment can be started and stopped manually from the graphic display. In AUTO, the equipment will be controlled according to the PLC programming, or, if there is no automatic control logic, then the control will be manual only from the SCADA graphic display. Control modes and functions will be password-protected.

7.8.4.3 General Equipment Monitoring Requirements

Equipment status and selected operating modes will be displayed on the SCADA system. Individual equipment runtime will be accumulated, logged, and displayed by the SCADA system. An operator with the proper access rights will be able to individually (or group) reset these values through SCADA. Alarm contacts for equipment interlocking, alarming, and resetting will be provided as direct inputs to the PLC. Alarms will be annunciated through SCADA. PLCs, including package systems, will be interfaced with the facility SCADA system.

7.8.4.4 SCADA Server Design Criteria

HMI system software will be the current version of Rockwell Automation FactoryTalk View Site Edition.

SCADA workstation software will be Microsoft Windows, including latest service packs, Microsoft Office Basic (latest version and service packs), and anti-virus software.

SCADA server software will be the latest version of Microsoft Windows with Media Kit (latest version and service packs) and anti-virus software.

SCADA servers will be virtualized to minimize hardware cost and facilitate system administration and maintenance.

7.8.4.5 Network Architecture

Overview

The plant’s communications networks will primarily use ethernet. Transmission of data between programmable logic controllers, SCADA systems, operator interfaces, controllers, engineering workstations, and so forth throughout the project will be 1,000-Mb internet protocol (IP) ethernet traffic (fibre optic or Category [Cat] 6 copper). Separate segregated networks will be provided for SCADA functions, business functions, and fire alarm control panels. Firewalls will be used to provide a DMZ between the business and SCADA networks, which will allow data access to outside users without risking each network’s security. Radio links will be used for SCADA monitoring of the remote water distribution sites.

General Considerations

- Fibre optic cabling will generally be used for network links between the WTP and the RWPS. The project will use multi-mode fibre optic cable.
- Cat-6 copper cabling will generally be used for ethernet connections within the treatment plant building.
- Fibre optic patch panels, copper patch panels, SCADA network ethernet switches, and business network ethernet switches will be housed within dedicated network interface panels (NIPs). This approach will allow information technology (IT) staff to maintain most of the network equipment with minimal risk of electrical hazards such as shock and arc flash.
- The servers for business and SCADA functions will be rack-mounted in a treatment plant server room.

- Separate networks will be provided for PLC remote input/output (I/O). The remote I/O devices will be connected via Allen-Bradley's device-level ring.

Business Network

The business network will connect equipment used for the facility's business functions, including telephones and security. Virtual local area networks (VLANs) will be used to segregate the network traffic. Additional input is required for the business network functions. This system will be developed further during final design.

DMZ Network for Remote Access

The facility will include continued secure exchange of SCADA/instrumentation information presently available for remote monitoring through internet connection. A DMZ network will be provided at the WTP site to accommodate access to the plant's SCADA and business network data by external staff and systems. This will be the access provided for remote SCADA view. Firewalls will be used to separate the DMZ network from the SCADA and business networks.

VPN Tunnels

VPN tunnels use encryption to make a secure connection between sites through the internet. VPN tunnels are secure and used by government and major corporations to connect remote networks together. VPN tunnels will be used on the SCADA and business networks for secure connections to remote facilities.

Fire Alarm Control Panel Network

Additional input is required for the business network functions. This system will be developed further during final design.

7.8.5 Instrumentation Design Criteria

7.8.5.1 Local Control Stations

Controls mounted adjacent to the controlled equipment will be provided with a HAND/OFF/AUTO selector switch. Valves and similar equipment will be provided with a LOCAL/REMOTE selector switch and OPEN/STOP/CLOSE pushbuttons.

Local control stations will be provided at each piece of equipment controlled by an adjustable frequency drive (AFD), unless pumps are in the vicinity of the AFD. Local control stations for equipment with AFDs will also include a speed control potentiometer. The PLC will have no control over the equipment when LOCAL is selected.

7.8.5.2 MCC Controls

Local controls will be provided on the motor control starters as well as the standard circuit breaker, hardwired interlocks, and the overload and hardwire interlocks reset. AFDs will be connected to the PLC system via hardwire interface.

7.8.5.3 Safety Interlocks

Safety and equipment protection shutdown/lockout interlocks will be implemented through hardwired connection to the motor control circuit. Interlocking for personnel and equipment safety and equipment protection will not be done through the PLC or SCADA systems. Interlock logic will include a local RESET pushbutton at the MCC. Shutdown/lockout and RESET functions will be monitored by the PLC and SCADA systems to preclude automated system operation in the event of a shutdown/lockout.

7.8.5.4 Programmable Logic Controllers and Locations

Individual PLCs will be located in the various process areas, or in electrical rooms near the process areas they serve. A preliminary list of PLCs is provided in Table 7-13.

TABLE 7-13
PLC Locations

PLC Number	Location	Service	Comments
xxPLC01	Raw water pump station	Raw water	By package system supplier
xxPLC01	UV area	UV	By package system supplier
xxPLC01	UF membrane area	Membranes and subsystems	By package system supplier
xxPLC01	Electrical room	Balance of plant systems	

PLC = programmable logic controller
UF = ultrafiltration
UV = ultraviolet

7.8.5.5 PLC Design Criteria

For large PLCs, the PLC system will use Allen-Bradley ControlLogix. For small PLCs, the PLC system will use Allen-Bradley CompactLogix. The current version of RSLogix 5000 software will be used to program all PLCs. The PLC software provided will be compatible with the PLC hardware provided. The software required for the PLC comprises the following types of components:

- Latest version of fully licensed PLC programming and configuration software, RSLogix5000
- Latest version of fully licensed communications software and drivers for supplied PLC to PC communication, RSLinx Professional

Distributed PLC processors, networks, and PLC power supply units will provide system reliability for all PLC and HMI systems.

PLC I/O properties:

- Digital inputs will be powered by 120-V alternating current (AC; coordinate with electrical) optically-isolated, channel-to-channel
- Digital outputs will be isolated dry relay contacts rated for 120-V AC (coordinate with electrical) for hardwired circuit operation
- Analog inputs will be 4- to 20-milliamp (mA) direct current (DC), optically isolated, channel-to-channel signals from powered transmitters or 24-V DC loop-powered from the PLC cabinet
- Analog outputs will be isolated 4- to 20-mA DC signals

7.8.5.6 Package System Controls

Some instrumentation and controls will be furnished with packaged control systems, including PLCs, by the equipment manufacturer. The package system controls will include PLC data I/O for data monitoring with the plant SCADA system network. PLCs will be from the same manufacturer as the SCADA system.

The package systems anticipated for the project are:

- Membrane (membrane master PLC with remote I/O (RIO) at each membrane rack
- UV

7.8.5.7 Enclosures and Panels

A local control panel will be provided for each PLC. All enclosures and panels will be Underwriters Laboratories of Canada (ULC)-listed and National Electrical Manufacturers Association (NEMA)-rated.

Panels will be continuously welded, seamless NEMA 12 enclosures with single front access and either single-door or multiple-door construction. Panels will have full-size 10-gauge mounting plates. Enclosures and panels will be located in control rooms, or in electrical rooms if control rooms are not available.

24-V DC power supplies will be sized for 50 percent load utilization. Where loads are critical, redundant power supply configurations will be provided.

Within control panels, all field wiring will be terminated at terminal blocks. 120-V AC power supply wiring will be connected using the following procedures:

- Within control panels, protect individual 120-V AC circuits powered from the UPS with DIN-mounted circuit breakers
- Feed instruments' 120-V AC power circuits from the control panels; provide fused protection for each 120-V AC instrument power circuit

7.8.5.8 Uninterruptible Power Supply

Each PLC control panel will be provided with backup power during power failure transitions from an uninterruptible power supply (UPS). The UPS will provide a reliable source of uninterruptible power with no break in air conditioning output power during a complete or partial interruption of incoming line power. The UPS will include audio/visual alarms and will be UL-listed. UPS status (health) will be monitored by the SCADA system.

The UPS will have the capacity to power the connected load for 30 minutes and will power the following control system elements:

- PLC
- I/O
- Field instruments
- Local network switches and media converters
- 24-V DC regulated power supply

7.8.5.9 Field Instruments

Field instruments will have the following properties:

- Field instruments requiring power will be suitable for 120-V AC 60 Hz. Field instruments requiring 24-V DC will be loop-powered.
- All instrumentation supplied will be of the manufacturer's latest design and will produce or be activated by signals that are established standards for the water industry.
- All electronic instrumentation will use signals of 4- to 20-mA DC.
- All instruments will be provided with a stainless steel tag, mounting hardware, and mounting appurtenances.
- All indicators and recorder readouts will be in process units unless otherwise noted.
- Equipment, cabinets, and devices furnished will be heavy-duty type, designed for continuous industrial service. The system will contain products of a single manufacturer as possible and will consist of equipment models that are currently in production. All equipment provided will be of modular construction and be capable of field expansion.
- Diaphragm seals or annular seals suitable for the fluid and pressure range will be used to keep corrosive chemicals and solids out of pressure instruments.

Flow Instruments

- Magnetic flow meters and thermal mass flow meters will be used for most applications

Level Instruments

The following level-sensing instruments will be used:

- Ultrasonic or radar level-monitoring system for non-contact applications such as wet wells and chemical tanks
- Submerged hydrostatic pressure level-measuring systems
- Float-type, or tuning-fork-type, level switches for sumps and where required for backup of high- and low-level applications

Pressure Instruments

The following pressure instruments will be used:

- Process pressure transmitters for absolute, gauge, and differential pressure monitoring
- Diaphragm-type pressure switches

Temperature Instruments

Process temperature transmitters will be 4-wire 100-ohm resistance temperature detector (RTD) type with 4- to 20-mA DC temperature transmitters

Analyzers

The following analyzers will be used:

- Reagentless amperometric free and total chlorine sensor
- pH transmitters – probe and transmitter, NEMA 4X
- Low-range turbidimeters

Other analytical instruments will be defined during design.

7.8.5.10 Environmental Conditions

PLC panels will be located in controlled environments in buildings wherever possible.

7.8.5.11 Corrosive Locations

Equipment to be located in areas subject to corrosive fumes or spills will be designed of materials for use in these corrosive areas. Corrosive area locations for PLCs, panels, and so forth will be avoided wherever possible.

7.8.5.12 Equipment Enclosures

All equipment enclosures will meet the following requirements:

- NEMA 12 – General purpose indoor areas and electrical rooms
- NEMA 4 – Outdoor areas (cooled and heated)
- NEMA 4X – Corrosive and/or outdoor corrosive areas

7.8.5.13 Sunshields

Field instruments and panels may be equipped with sunshields to allow viewing of the displays and/or to shield the instrument enclosures from the heating effects of direct sunlight.

7.9 Building Mechanical

7.9.1 Codes, Standards, and Regulations

Codes and standards for the project include:

- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) design and data manuals

- 62.1, Ventilation for Acceptable Indoor Air Quality, 2010 edition

- American Society of Mechanical Engineers (ASME)
  - B31.3, Process Piping
  - B31.9, Building Services Piping
- British Columbia Building Code, 2012 edition
- British Columbia Fire Code, 2012 edition
- British Columbia Plumbing Code, 2012 edition
- CSA
  - B51, Boiler, Pressure Vessel, and Pressure Piping Code
  - B52, Mechanical Refrigeration Code
- National Fire Protection Association (NFPA)
  - 13, Standard for the Installation of Sprinkler Systems
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
  - Duct Construction Standards
- Underwriters Laboratories of Canada (ULC)

7.9.2 HVAC System Design Criteria

7.9.2.1 Climate

Table 7-14 shows the outdoor climatic data for the project site.

TABLE 7-14
Outdoor Design Conditions

Design Criteria	Value
Weather data location	Parksville, BC
Site elevation	40 m above mean sea level
Winter temperature	–6 °C, January 2.5%
Summer temperature	26 °C dry bulb, 19 °CF wet bulb, July 2.5%
Climate	**Value**
Heating degree days	3,200 heating degree days below 18 °C
15-min rain event	10 mm
Annual rainfall	1,200 mm

Source: Appendix C of the National Building Code of Canada 2010

7.9.2.2 Ventilation

According to the ASHRAE 62.1 standard, an occupied space is an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as process spaces, electrical rooms, and equipment rooms, that are only occupied occasionally and for short periods of time. Since all the process spaces are designed to be occupied only occasionally, ASHRAE 62.1 does not specify a minimum continuous ventilation rate requirement. Table 7-15 specifies the proposed ventilation rates for each space in this facility.

TABLE 7-15
Ventilation Criteria[a]

Building	Space	Design Ventilation Rate L/s/person	L/s/m^2	Air changes/hr	References
Water treatment building	Process area (membranes, electrical, strainers, UV)	N/A	0.3		Good engineering practice
	Chemical Room	N/A	7.5	N/A	ASHRAE 62.1
	High Lift Pumping Station room	N/A	N/A	Heat Relief	
	Utility Room	N/A	5.0	N/A	ASHRAE 62.1
	Lab room	2.5	0.3	N/A	ASHRAE 62.1
	Control room	2.5	0.3	N/A	ASHRAE 62.1
	WCs	25/unit	N/A	N/A	ASHRAE 62.1
	Server Room	N/A	5.0	Heat relief	
Raw water pump station	Pump room	N/A	N/A	Heat Relief	

Notes:
According to ASHRAE 62.1, Table 6.2.2.1, Minimum Ventilation Rates In Breathing Zone, and Table 6.5, Minimum Exhaust Rates
L/s/m^2 = litres per second per square metre

Indoor design temperature will be controlled to meet Building Code Requirement as well as the process needs. Table 7-16 provides the indoor design temperature for the proposed spaces.

Building	Space	Design Temperature, °C Summer	Winter
Water treatment building	Process area	35	5
	Chemical Room	35	5
	High Lift Pumping Station room	35	5
	Utility Room	35	5
	Lab room	24	22
	Control room	24	22
	Server Room	24	22
Raw water pump station	Pump room	35	5

7.9.3 Heating, Ventilation, Air Conditioning, and Cooling Equipment

7.9.3.1 General

The occupied (non-process) spaces will typically have heating, ventilation, and air conditioning (HVAC). Unoccupied (process) spaces will have heating and ventilation cooling (HVC). Both types of spaces will be provided with forced ventilation (excluding the chemical areas) and outside-air MERV 8 synthetic media filters. The following discussions present HVAC and HVC concepts for specific spaces or buildings.

7.9.3.2 Water Treatment Building

High Lift Pumping Station Room

- Cooling is provided by transferring warm air to adjacent cooler Process Area via supply fans, the cooled air is then returned to the High Lift Pumping Station Room
- Raw water cooling coil to be installed in the duct work to further cool the return air if required
- Heating is provided by electric unit heaters

Process Area

- Heating is provided by transferring warm air from the High Lift Pumping Station Room to the Process Area
- Electric unit heaters to be provided in the perimeter walls to supplement the heating requirement

Chemical Room

- Continuous ventilation is provided by exhaust fans working in conjunction with a Make-up Air Unit (MAU)
- The MAU consists of a blower section, filter section, electric heating coil and intake/discharge dampers. The MAU shall be located within the Chemical Room

Utility Room

- Ceiling mounted exhaust fans to ventilate space
- Heating provided by electric baseboard heater

Lab Room

- Ductless spilt air conditioning system with heat pump capability shall be provided to meet heating and cooling requirements
- Additional heating provided by election unit heaters
- Small exhaust fan above sample working area

Control Room

- Ductless spilt air conditioning system with heat pump capability shall be provided to meet heating and cooling requirements
- Additional heating provided by election unit heaters

WCs

- Ceiling mounted exhaust fans to ventilate space
- Heating provided by wall mounted baseboard heaters

7.9.3.3 Raw Water Pump Station

Pump Room

- Cooling ventilation provided by filtered supply fans c/w gravity relief
- Heating provided by electric unit heaters

7.9.3.4 Equipment Location

Water treatment plant and raw water pump station HVAC equipment can be located in the space being served or on the mezzanine.

7.9.3.5 Ductwork

Ductwork materials of construction will depend on the installation location. Aluminum ductwork will be used for the most spaces. Ductwork materials for the chemical storage areas will be selected based on the space environment, and may include FRP or stainless steel. Future design phases will identify the specific materials of construction.

7.9.4 Plumbing Systems

Domestic plumbing systems will serve the water closets, Lab room sink, washrooms, emergency safety showers, and floor drains in various locations. Plumbing fixtures will be of commercial quality and ADA-compliant.

7.9.4.1 Emergency Safety Showers

Emergency safety shower fixtures will be located in the chemical areas and outside the WTP near the unloading area. Quantity and location of emergency safety showers will be determined later as the building layout is finalized. Location criteria include travel distance, impediments to travel, and number of spaces. Outdoor units will be freeze-resistant or designed such that exposed piping is heat-traced.

7.9.4.2 Potable Water

Water Treatment Plant

Water service to the WTP will be provided from the existing 200-mm-diameter PVC main on Herring Gull Way. A water meter and pressure regulator will be provided. Potable water will serve the plumbing fixtures in the building as well as the emergency safety showers. Non-potable water will be provided for applications such as the hose stations and pump seals, as required.

An electric hot water tank c/w water recirculating pump will be used to supply domestic hot water to all plumbing fixtures. Tempered water system will be provided to service the emergency showers. All domestic hot and cold water piping will be insulated with pre-formed fiberglass pipe insulation with vapor barrier jacket. Sanitary vent piping through the roof will be insulated for a distance of 3 feet inside the roof envelope.

Raw Water Pump Station

Water service to the RWPS will be provided from the WTP. Only non-potable water will be provided for applications such as hose stations and pump seals, as required. Potable water will not be provided to the pump station.

7.9.4.3 Sanitary Waste

Water Treatment Plant

Sanitary waste from plumbing fixtures will be directed to the sanitary drain system in the WTP. Sanitary waste and vent piping will be included in the design. Floor drains will be collected and directed to the WET tank.

Raw Water Pump Station

RWPS floor drains will flow by gravity to a drain sump, which a vacuum truck will empty intermittently.

7.9.4.4 Process Drainage

A trench drain and sump are planned for the below-grade utility chase. The sump pump will discharge to the WTP’s process waste system.

7.9.4.5 Chemical Area Drainage

Local sumps in the individual chemical areas will allow collection of spilled chemicals. A portable will be used to remove any spilled chemicals and wash water.

The outdoor chemical loading area will also include a chemical spill collection system.

7.9.4.6 Roof Drains

Roof drainage for the WTP and will be directed to the storm water system. Interior roof drains and overflows will be insulated.

7.9.5 Fire Protection Systems

As the design progresses, a hazardous material and code analysis will be performed to determine fire protection requirements for the project, specifically for interior chemical spaces. Specific sprinkler and stand pipe requirements for the various spaces and buildings will be reviewed with the fire marshal to determine the path forward.

SECTION 8

Implementation Plan

8.1 Equipment Procurement

The procurement options applicable to this project are summarized in TM 5, *Project Implementation*, included as Appendix I. TM 5 recommends a combined approach of pre-purchasing equipment and "name-specifying" manufacturers to procure the required equipment and materials.

8.1.1 Pre-purchased Equipment

Pre-purchasing is typically used for equipment with long delivery lead times or when specific equipment details are required to complete the design. The membranes system including raw water pumps and chemical systems is proposed for pre-purchase. It is expected that other equipment can be adequately specified and delivered to meet the construction schedule.

8.1.2 Name-Specified Manufacturers

Name-specifying manufacturers typically involves detailed technical review of vendors' equipment and/or systems to identify a list of manufacturers to be included in the construction contract documents. The preferred vendor is the "first named," and the remaining vendors are "acceptable alternative" manufacturers in the contract documents. The following equipment is proposed to be name-specified:

- Intake screens
- Pre-filtration strainers
- Compressors
- Pumps (excluding raw water pumps)
- Motors
- Valves
- Electrical control equipment (MCCs and PLCs)
- Transformers
- Lighting fixtures
- Instrumentation

The ERWS and CH2M HILL will determine the name-specified manufacturers at the beginning of detailed design.

8.2 Contracting Options

The project will consist of the following construction tasks:

1) Contract #1
   a) Intake and raw water pump station
   b) Raw water main
   c) Water treatment plant and highlift pump station
   d) Site Works
   e) Common transmission main from WTP to bifurcation point by river.
   f) Connections of two transmission mains in contract 2 to RDN and Springwood reservoirs.
2) Contract #2
   a) Two new transmission mains from bifurcation point by river to the RDN and Springwood reservoirs.

8.3 Construction Schedule

Table 8-1 shows a schedule of milestones for implementation of the project. To meet the IHA requirement of WTP operation by mid-2018, the work must commence in contract 1 by August/September 2016.

TABLE 8-1

Schedule of Project Milestones

	START DATE	END DATE
Intake, Pump Station, Water Treatment Plant		
Membrane System (Procurement and Award)	October 2015	November 2015
Proof Pilot Testing (Membrane)	December 2015	March 2016
Detailed Design	November 2015	June 2017
30% Detailed Design	November 2015	February 2016
60% Detailed Design	March 2016	May 2016
90% Detailed Design	June 2016	June 2016
Tendering	July 2016	August 2016
Construction		
Water Treatment Plant	October 2016	December 2018
Intake and Pump Station, Transmission Main Crossing	August 2017	September 2017
Distribution (Transmission Mains)		
Preliminary Design	August 2015	November 2015
Detailed Design	November 2015	June 2016
30% Detailed Design	November 2015	February 2016
60% Detailed Design	March 2016	May 2016
90% Detailed Design	June 2016	June 2016
Construction		
Transmission Mains	October 2016	October 2017

SECTION 9

Cost Estimate

This section presents the predesign cost estimate.

9.1 Cost Summary

Table 9-1 shows a breakdown of the cost estimate. All costs are shown in Canadian dollars, include PST and do not include engineering. A detailed breakdown of the cost estimate is included in Appendix N. The costs identified in Table 9-2 are included in the cost estimate and represent new scope added to the project in this phase (after September 2015).

TABLE 9-1.
Predesign Estimated Costs[1] ($CDN)

	Funding Source	-30% Estimated Costs	Predesign Estimated Costs	+50% Estimated Costs
Intake and Raw Water Pump Station	ERWS	$1,550,000	**$2,210,000**	$3,320,000
Raw Water Main	ERWS	$1,620,000	**$2,320,000**	$3,480,000
Water Treatment Plant	ERWS	$9,720,000	**$13,240,000**	$19,860,000
Siteworks	ERWS	$1,380,000	**$1,970,000**	$2,960,000
Transmission Mains	CoP	$4,330,000	**$6,190,000**	$9,280,000
Transmission Mains	ERWS	$620,000	**$890,000**	$1,330,000
Project Costs 2017		**$18,770,000**	**$26,820,000**	**$40,230,000**

Note:

1. Costs include 7% PST, 25% contingency, and do not include engineering

TABLE 9-2.
Predesign Estimated Added Costs[1] ($CDN)

	Estimated Cost	Note
Standby power Generator	$1,200,000	Added at the request of ERWS
Escalation	600,000	Increase in escalation from 2.71 to 4.06% due to project being postponed by 14 months.
W1 transmission main retaining wall	241,000	340 retaining wall identified during survey and pipe alignment development
W2 transmission main – access road from Chattel road to intake	$96,000	Added at the request of ERWS
Total Adder Costs 2017	**$2,137,000**	

Note:

1. Costs include 7% PST, 25% contingency, and do not include engineering

9.2 Estimate Classification

This is a Class 4 cost estimate as defined by the Association for the Advancement of Cost Engineering International (AACEI). The expected accuracy range for a Class 4 estimate is –30 percent to +50 percent.

9.3 Scope of Estimate

This estimate provides costs for the following components of the project:

- Intake and Raw Water Pump Station
  - Obermeyer weir
  - Intake structure with fish screens
  - Piping from intake structure to the RWPS
  - RWPS building
  - Pump cans
  - Vertical turbine pump

- Raw Water Main
  - Raw water main transmission line
  - Duct bank
  - Access Road
  - Storm drain improvements
  - Railroad Crossing

- Water treatment plant
  - Pre-engineered WTP building
  - UF membrane system
  - Chemical systems
  - UV disinfection system
  - Chlorine disinfection
  - Clearwell
  - Pipe chase
  - Treated water pump station
- Siteworks
  - Yard piping
  - Demolition
  - Site grading
  - Paving
  - Curbs
  - Landscaping
- Transmission Mains
  - Construction of W01 and W02 Transmission Mains

9.4 Methodology

This is a “bottom rolled up” estimate with cost items and breakdown of labour, materials, and equipment. Vendor price quotations for equipment were used where available.

CH2M HILL compiled this estimate, with input from KWL and Golder. The project elements were categorized according to the following areas of responsibilities:

- CH2M HILL
  - River Intake Structure and Weir
  - Raw water pump station
  - Water treatment plant
- KWL
  - Pipelines
  - Treated water pumps
  - Site civil
  - Landscaping
- Golder
  - Geotechnical
  - Archaeological

9.5 Assumptions

The following assumptions were made in developing this estimate:

The contractors will be considered equal and will be selected using a competitive bidding process
Construction duration will be reasonable (an “accelerated schedule premium” will not be required)
Construction materials and equipment will be available domestically

9.6 Markups

Table 9-2 shows the assumed contractor markups that will be applied to the project.

TABLE 9-3
General Contractor Markups

	Markup (%)
Prime contractor general conditions	7.00
Prime contractor overhead	10.00
Prime contractor profit	5.00
Builders risk and liability	2.00
Payment performance bond	1.50
Level of design contingency	25.00
Escalation to midpoint of construction (April 2017)	4.06

The actual markup percentages will vary depending on the contractor and market conditions.

9.7 Escalation Rate

This CH2M HILL escalation forecast is based upon economic data from Global Insight, Inc. for forecast data (10 years) and the United States Bureau of Labor Statistics for historical data (10 years). A specific Water Treatment Plant index was developed by CH2M HILL, using 31 key construction commodities. See the escalation calculation sheets in the cost estimate for details. The escalation is based on the first part of the construction starting in September 2016 and being complete by February, 2018. The estimate is escalated to the Midpoint of construction which is assumed to be April 2017. Assumed average escalation of 3% per year (3% x 1.34 years to Midpoint).

9.8 Labour Costs

This cost estimate has been adjusted for local area labour rates, based on 2014 RSMeans rates for Vancouver, British Columbia.

The labour unit prices reflect a burdened rate, including workers compensation, unemployment taxes, fringe benefits, and medical insurance.

The "Employment Standards Act of British Columbia", is legislation enacted by the provincial government of British Columbia to protect the rights of working people. Sections within the act outline the employer's responsibility to their employees, notably things such as minimum wage, meal breaks, and parental leave. The act also works to protect residents of the province by preventing employment discrimination.

9.9 Taxes

GST tax is excluded and Provincial Sales Tax (PST) was added at 7%.

9.10 Allowances

This estimate includes allowances for known work for which the design has not been sufficiently developed at this time:

- Electrical work
- I&C work

9.11 Excluded Costs

This estimate excludes the following costs:

- Engineering design costs
- Land, legal, and other owner administration costs
- Material adjustment allowances

9.12 Cost Resources

The following resources were used in developing this estimate:

- RSMeans
- CH2M HILL historical data
- KWL historical data
- Golder historical data
- Vendor quotes on equipment and Materials where appropriate
- Estimator judgement

Appendix A
Drawings

Appendix B
TM #1 – Permitting Requirements, Status, and Compliance Plan

Appendix C
TM #2A – Intake Hydrology and Hydraulics

Appendix D
TM #2B – Arrowsmith Lake Reservoir Water Supply

Appendix E
TM #2C – Intake, Raw Water Pump Station, and Transmission Mains

Appendix F
TM #3 – Raw Water Quality Sampling Program

Appendix G
TM #4A – Distribution System Upgrades – Water Demands

Appendix H
TM #4B – Distribution System Upgrades – Water Modelling

Appendix I
TM #5 – Project Implementation

Appendix J
Aquatic Effects Assessment

Appendix K
Pre-Design Geotechnical Investigation

Appendix L
Archaeological Overview Assessment