Westside Wastewater Treatment Plant Siting Analysis – Phase 2 Report

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Appendices

1.0 Report Summary and Study Overview

The Westside Select Committee terms of reference guided recent analysis for potential distributed and sub-regional treatment systems. Led by Westside Technical Staff, recent analysis builds from sites and option set development in 2015 to provide advanced feasibility reporting for three options: 1-plant, 2-plant and 4-plant solutions. Phase II objectives include:

- Conduct technical analysis using current public input and wastewater data
- Study wastewater treatment technologies including liquids and solids treatment
- Explore resource recovery pathways including water reclamation and solids-energy recovery
- Assess the regulations and identify varying levels of service for further consideration by the Committee
- Include conceptual costing as well as preliminary revenue projections for resource recovery
- Reprioritize the Westside sites for further consideration by Westside Technical Staff and the Select Committee

Interim findings were presented to the Westside Select Committee on September 29, 2015 for further discussion and direction on each of the study objectives. The interim presentation provided for a progressive discussion regarding flow conditions, resource recovery methodologies, solids recovery strategies, regulatory considerations and treatment technologies. Key takeaways from September 29 included direction to conduct analysis on the integrated flow scenario, whereby Westside option sets incorporate flows from west Saanich and west Victoria, and, direction by the Committee to study and report on highest-potential solids recovery approaches, given factors such as distributed, centralized and integration with municipal yard and kitchen waste.

This report includes six technical chapters which cover design criteria, resource recovery, solids management and review of each option set (1-plant, 2-plant and 4-plant). Section 1.1 isolates key findings for further discussion and direction and provides a strong basis for subsequent technical and life-cycle analysis. Opportunities to achieve similar or higher levels of service at lower costs may be possible following Core Area feasibility analysis by way of finding resource recovery synergies, reducing infrastructure needs and or minimizing redundant facilities.

1.1 Key Findings from Phase 2

1.1.1 Representative Design Approach

- Representative design includes provisional selection of technologies to develop order of magnitude costs. Technologies are selected to suit the project criteria but should not be considered the solution as private sector responses are critical to confirming the actual facilities built.

1.1.2 Solids Management and Recovery

- Wastewater solids are comprised of many materials and provide for a diverse range of recovery possibilities, such as nutrients, energy, bioplastics, biofuels and carbon dioxide (among others). Converting wastewater solids into valued resources requires customers, risk, investments and often, tenured financial partnerships. There are myriad ways to recover resources from wastewater solids which extends the resources required for broad studies. Instead, wastewater utilities often canvass the private sector for financially-backed solutions to meet a list of explicit objectives as stated by the Owner. Proponents detail how their solution addresses the Owner's requirements and responses include confirmation of end-uses, customers, risk management, costs and revenues. While Core Area analysis will further explore solids management and recovery, recent Westside analysis explored the potential for integration of solids recovery with municipal solid waste such as kitchen scraps and yard/garden waste.
- Gasification of municipal sludge (e.g. cake) with municipal yard and kitchen waste appears to provide a similar long-term cost and value proposition as anaerobic digestion of wastewater solids (only). However, gasification of sludge without yard waste does struggles to achieve energy neutrality. At the time of this report, technical analysis continues regarding the storage, handling, trucking, revenue potential and residual solids management methods (e.g. creating new markets for biochar, among others). Carrying the cost for either gasification or anaerobic digestion in representative design cost estimates does not appear to significantly affect the overall cost estimating at this time. As noted above, results from Core Area analysis may further suggest that that approaching the private sector with a Request for Statements of Interest (RFSI) for either technology would maximize the efficiency of the market.
- Five conditions encourage a centralized approach to energy-solids recovery:
  - Multiple small plants are overall less efficient than one larger facility (important in order to optimize recovery and revenues)
  - Multiple small plants do not negate the need for a larger solids processing facility at one location (to account for the 0-4xADWF flows), meaning that additional plants may be redundant and costly
  - Multiple small plants will require redundant heat/energy delivery infrastructure or gas-upgrading systems which have capital and operating costs;

  - Trucking patterns for one facility would be relatively simple compared to the ins-outs of multiple smaller facilities
  - Most sites throughout the Westside are not large enough to host both liquids and solids treatment, in particular when three or four times the feedstocks are temporarily stored for gasification

- Resource recovery activities at Hartland Landfill should be explored further to define the benefits of integration with municipal yard and kitchen waste as well as to uncover the synergies of linking technologies with resource recovery efforts (e.g. methane gas capture) already underway at the Landfill. A key issue in future phases will be to identify the future market for all residual solids downstream of the preferred recovery technology to avoid the cost of landfilling byproducts until suitable markets are confirmed.

1.1.3 Water Reuse and Recovery Systems

- Core Area water customers receive service from CRD Water with adequate supply from Sooke Reservoir. Treated effluent reuse could help to mitigate future potable water supply issues caused by climate change or population growth (among other drivers).
- Target markets for water reclamation typically include clusters of high-water use demands such as parks, green spaces, aquifer recharge and future growth centers (based on treated effluent used for toilet flushing). Next steps in water reuse should look to identify new customers (i.e. new markets) for water reuse to grow water revenues to offset capital + operating costs.
- Growth and development as well as lands in and around the North Colwood site node present the highest water reuse possibilities, including, the potential for aquifer recharge throughout the year. Further feasibility analysis is being conducted by Colwood to determine the reliable potential for aquifer recharge and those effects on infrastructure systems. Two reuse systems in Colwood-Langford and Esquimalt (with some coverage of View Royal lands) provides for relatively efficient strategy to provide for water reuse via clustered infrastructure systems.
- Phasing-in water reclamation systems (e.g. purple pipe) over time helps to align infrastructure investments with the timing of actual water needs. With a potential system built in Colwood, Westside communities could consider expanding water reclamation systems to suit potable water supply challenges over time in addition to aquifer recharge.
- Treatment plants are designed to renovate wastewater for re-entry to the environment. Recent Westside analysis suggests that a sustainable water recovery strategy can include:
  - reclamation for irrigation of up to 400 hectares,
  - aquifer recharge for most flows in Colwood and perhaps more from treated flows Langford over time,

  - indirect potable reuse for toilet flushing in growth centers (in addition to any other grey-water reuse strategies that may also be considered), and
  - the potential to treat almost all flows in excess of the regulations by way of tertiary treatment via membranes (part) and disinfection (all).
- Recent information points to increased aquifer recharge which should also be explored further in Phase 2: Core Area. Life cycle costing can inform the desired level of service for water recovery.

1.1.4 Life Cycle Costing Considerations

- Costing models are based on a construction schedule that begins in 2018 with commissioning in 2023. Preliminary cash flow analysis is based on system capacities to suit the 2030 flow scenario over a 7-year analysis period. Longer-term analysis is needed for decision making but cannot be completed until 2045 capital projects have been considered and more accurate revenue projections been developed. Preliminary analysis still provides important insights into option set financial feasibility.
- Multiple, smaller-scale facilities reduce beneficial economies of scale for construction, reduce efficiencies, increase the number of pumps and length of pipes, and increase overall site improvement costs which create higher life-cycle costs for the 4-plant option. The 1-plant option provides greater efficiencies, increases economies of scale, reduces the extent of new infrastructure and demonstrates the lowest costs.
- Revenues for water reuse are set to be phased in as customers confirm partnerships with CRD or the municipality for service. Revenues from water re-use will be challenged to cover the operating and capital financing costs of their delivery systems.
- Revenues for heat recovery are largely confined to offsetting the costs of processing heating and energy needs at the plant(s). Finding a reliable market for biochar or biosolids will significantly affect the preliminary life-cycle feasibility of either technology. Preliminary analysis assumes that a market for a biochar must be developed at or less than the cost of landfilling. Revenues from carbon offsets for either anaerobic or gasification are still under development and therefore have not yet been accounted for in costing analysis.
- While the 1-plant option provides for the lowest life cycle costs up to 2030, the 2-plant option is appreciably less costly than the 4-plant option. The qualitative benefits of any option help to balance the financial weighting of the analysis with respect to other environmental, social and economic factors.

Option Sets Summary: Criteria Differentiators

A fulsome characterization of option sets against the Charter and technical criteria will be completed as Part of Phase 2 for the Core Area. Consider this preliminary table a snapshot into the characterization of the three option sets.

Criteria	
Leverage infrastructure and minimize operating costs	• The 1-plant option requires least new infrastructure and offers lowest operating costs; the 2-plant option is notably less expensive than the 4-plant option
Long-term revenues and resource demands	• The 2-plant option best meets the supply-demand, and achieves high efficiencies for water and solids recovery
Include other waste streams	• All options consider integration with municipal-garden waste at the Esquimalt Nation site
Includes capacity phasing	• The 1-plant option allows for the most efficient capacity phasing however 2-plant and 4-plant options allow for capacity increases adjacent where growth is to occur
Carbon, energy and footprint (physical area)	• The 1-plant option demonstrates the greatest energy and carbon footprint; the 4-plant option involves smaller facilities throughout
Positive and safe public interaction	• Smaller facilities of the 2-plant and 4-plant options provide a higher level of service and allow for enhanced massing for neighborhood fit; all facilities should be designed for safe interaction and to suit the local context
Extent of water quality in excess of regulations	• Each option set provides for enhanced tertiary treatment to varying levels: 4-plant includes ~40% to tertiary levels; 2-plant includes ~15% to tertiary levels; 1-plant to ~5% of tertiary levels

1.1.5 Site Findings

- Langford Site 2a at Meaford, Colwood Site 11 ‘Park and Ride’, Colwood Site 14 ‘Juan de Fuca Recreation Centre’, Esquimalt Nation Site 15, Bullen Park Site 17 and View Royal Site 16 ‘Burnside’ are preferred technical sites because they present advantages over other sites due to infrastructure and sizing considerations. Site 17 demonstrates low overall feasibility against the other five sites due to its size however synergies with Eastside facilities may reduce the footprint of any plant in Esquimalt. Further analysis in Phase 2 will explore this possibility in greater detail.
- Esquimalt Nation site poses the greatest feasibility for both liquids and solids treatment for the Westside (if sub-regional solids treatment is preferred).
- Gravel Storage Site 4 was not considered for 2030 design scenarios but can offer benefits to future sanitary system expansions as Westside communities continue to grow. Further consideration should be given to sites near Royal Bay for the 2045 scenario and beyond.

2.0 Design Criteria

2.1 Flows

All flows generated from Westside communities are currently discharged through the Macaulay Point Outfall. Partial flows from west Saanich and west Victoria also flow to Macaulay Point Outfall which triggers the need for Westside Solutions to consider treatment capacities for six of the seven municipalities in the Core Area.

Two recent milestones affect the design flows for this assignment:

- Direction from the Westside Select Committee to include the flows from west Saanich and west Victoria in the analysis
- Adoption by the Core Area Committee for 2030 flows for each municipality, which differ in the case of west Saanich and west Victoria from the flows initially provided at the start of this project

The inconsistency in flow estimates can be reconciled as part of Phase 2 feasibility and life-cycle analysis for the Core Area. For example, the cumulative flow estimates for the Core Area are relatively unchanged from previous estimates, however their distribution across west Saanich and west Victoria is what appears to have changed. Each of these flow scenarios in terms of average dry weather flows (ADWF) is summarized below in Table 2.1 Flow estimates to 2045 are provided as a provisional scenario for developing long-term site size requirements.

Table 2.1: 2030 and 2045 Design Flows

Location	Current	2030			2045 (2)		
	ADWF (MLD)	ADWF (MLD)	2 x ADWF (MLD)	4 x ADWF (MLD)	ADWF (MLD)	2 x ADWF (MLD)	4 x ADWF (MLD)
Langford	5.2	14.1	28.2	56.4	23.1	46.2	92.4
Colwood	2.2	4.7	9.4	18.8	13.1	26.2	52.4
View Royal	1.5	3.5	7.0	14.0	7.9	15.8	31.6
Esquimalt First Nation	0.1	0.7	1.4	2.8	0.4 (1)	0.8	1.6
Songhees First Nation	0.5	0.7	1.4	2.8	0.5 (1)	1.0	2.0
Esquimalt	4.9	6.2	12.4	24.8	7.9	15.8	31.6
West Victoria	5.4 (3)	1.0	2.0	4.0	6.8	13.6	27.2
West Saanich	16.4 (3)	16.5	33.0	66.0	32.9	65.8	131.6
Total	**36.2**	**47.4**	**94.8**	**189.6**	**92.6**	**185.2**	**370.4**

(1) Flows are not actually expected to decrease. This discrepancy is due to different sources of data which is not significant enough to affect analysis at this time.

(2) For derivation refer to Appendix A.

(3) Flows are not expected to decrease, this discrepancy is due to different sources of data.

Wastewater flows fluctuate throughout the day and throughout the year. As such, the Ministry of Environment and the LWMP have established certain treatment levels for different flows. The regulations, at minimum, require treatment facilities to treat 0 to 2 x ADWF to a secondary level. Flows from 2 to 4 x ADWF must be treated to a primary level and then can be combined with the secondary effluent for release through the Macaulay outfall. Flows greater than 4 x ADWF must be screened and then can be combined with the rest of the flows for discharge out the outfall. Table 2.2 summarizes the primary and secondary flows for the various option sets that were determined in the Phase 1 Report.

Table 2.2: Westside Design Treatment Flows

Option		2030 (MLD)		2045 (MLD)	
		Primary *	Secondary 2 x ADWF	Primary *	Secondary 2 x ADWF
1A	Esquimalt Village	189.6	94.8	370.4	185.2
1B	Esquimalt Nation	189.6	94.8	370.4	185.2
2A	Esquimalt Village	146.0	51.2	282.2	97.0
	View Royal	43.6	43.6	88.2	88.2
2B	Esquimalt Nation	47.4	47.4	90.0	90.0
	Esquimalt Village	142.2	47.4	280.4	95.2
2C	Colwood North	37.6	37.6	72.4	72.4
	Esquimalt Village	152.0	57.2	298.0	112.8
2D	Langford/Colwood	28.2	28.2	46.2	46.2
	Esquimalt Village	161.4	66.6	324.2	139.0
2E	Colwood South	37.6	37.6	72.4	72.4
	Esquimalt Village	152.0	57.2	298.0	112.8
4A	Langford/Colwood	28.2	28.2	46.2	46.2
	Colwood North	9.4	9.4	26.2	26.2
	View Royal	7.0	7.0	15.8	15.8
	Esquimalt Village	145.0	50.2	282.2	97.0
4B	Langford/Colwood	28.2	28.2	46.2	46.2
	Colwood North	9.4	9.4	26.2	26.2
	Esquimalt Nation	9.8	9.8	17.6	17.6
	Esquimalt Village	142.2	47.4	280.4	95.2

* Since the Macaulay outfall has no room for primary treatment facilities it is assumed the flows resulting from I/I (i.e., 2 to 4 x ADWF) will be treated as close to the Macaulay outfall as possible including any of the sites identified in the option sets.

2.2 Influent Wastewater Quality

The CRD collects 24 hour composite samples and tests the influent effluent for numerous parameters, as summarized in Appendix B. For convenience, Table 2.3 provides the most relevant influent sewage concentration data from 2014. This data is consistent with historical reports prepared for the Core Area LWMP, the latest being the January 23, 2013 Technical Memo "Indicative/Detailed Design/Wastewater Characterization and Design Loads". Table 2.3 also includes a summary of the 2030 maximum month loads, which are used to size the biological components of the plants. To account for flow and load variability, design factors account for the maximum load that the facility will experience in any 30 consecutive days which typically represents the 92 percentile of the data set analyzed for 2014. The proposed flow-load variability factor is set at 1.25 times the average loading.

Table 2.3 – Average Influent Quality Concentrations and Maximum Month Loads for 2030 Flows [(1)]

Parameter	Macaulay	
	Average (mg/L)	Max Month (kg/d)
Carbonaceous BOD_5	226	17,010
Total BOD_5	275	20,700
Total Suspended Solids	270	20,320
Chemical Oxygen Demand (COD)	632	47,560
Ammonia	42	3,160
Alkalinity	217	16,330
Total Kjeldal Nitrogen	54	4,060

(1) Note influent pH typically ranges from 7.3 to 7.7

2.3 Liquid Effluent Criteria

2.3.1 Introduction

Two regulations currently govern effluent discharges in BC – The Federal Wastewater Systems Effluent Regulation (WSER) and the BC Municipal Wastewater Regulation (MWR). The WSER deals only with discharges to surface waters and has marginally different criteria than the MWR. The MWR also defines indirect potable reuse applications which we understand to be an acceptable level of treatment for aquifer recharge based on work currently being undertaken by City of Colwood. Both provincial and federal governments intend to harmonize the regulations which will affect the effluent criteria.

There is a strong sentiment within Westside to reuse reclaimed water where feasible. To facilitate this sentiment, it is proposed that effluent destined for reuse meet the *Indirect Potable Reuse Category* for reclaimed water as defined in the BC Municipal Wastewater Regulation. This level of quality is more stringent than the requirements of the *Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing* and the California *Title 22 Regulation* and would permit all reclaimed uses except Direct Potable Reuse. Alternatively if reuse was limited to irrigation on restricted public access sites only, then the standard of effluent quality could be reduced to *Moderate Exposure Potential Category* which is basically equivalent to secondary treatment as defined in Section 2.3.4. Also, secondary treatment is suitable for discharge to most marine environments but the outfall depth must be positioned at 30 m depth or more which effectively rules out any discharge to the inner harbour.

Stream augmentation is cited in the regulations whereby treatment must be greater than secondary (i.e. must be tertiary) with effluent criteria to suit the receiving environment. However, MWR requires an alternate disposal or storage for reclaimed water (stream augmentation or reuse) as follows:

"Alternate Disposal or Storage

114 (1) A person must not provide or use reclaimed water unless all of the following requirements are met:

(a) There is an alternate method of disposing of the reclaimed water that meets the requirements of this regulation or is authorized by a director.

(b) Treatment processes are built with the minimum number of components specified in the applicable reliability category for the alternate method of disposal, as described in section 35 *[general component and reliability requirements]*;

(c) If there is no immediate means of conveyance of the municipal effluent or reclaimed water to the alternate disposal method, the wastewater facility has 48 hours' emergency storage outside the treatment system.

(2) Despite subsection (1) (a), a director may waive the requirement for an alternate method of disposal for reclaimed water that is not generated from residential development or institutional settings if an alternate method is not required to protect public health or the receiving environment and the wastewater facility has

(a) 48 hours' emergency storage outside the treatment system and the ability to shut down generation of municipal wastewater within 24 hours, or

(b) A dedicated storage system that is designed to accommodate:

i. At least 20 days of design average daily municipal effluent flow at any time,

ii. The maximum anticipated volume of surplus reclaimed water, and

iii. Storm or snowmelt events with a less than 5-year return period.

(3) Despite subsections (1) (a) and (2), if reclaimed water is discharged from a wastewater facility directly into a wetland, a director may waive the requirement for an alternate method of disposal if an alternate method of disposal is not required to protect public health or the receiving environment.

Failure to meet municipal effluent quality requirements

115 (1) If municipal effluent does not meet municipal effluent quality requirements, a provider of reclaimed water must ensure that the municipal effluent is diverted immediately to

(a) An alternate method of disposal, as provided for in section 114 (1) (a) *[alternate disposal or storage]*, or

(b) Emergency storage or a dedicated storage system, as described in section 115 (1) (c) or (2),

Until municipal effluent quality requirements are met and reclaimed water uses may continue.**"**

These regulatory requirements strongly suggest that access to an alternate ocean outfall is required if stream augmentation is pursued.

A discharge to a wetland may be possible without requiring an alternate method of disposal, but this would require a specific environmental impact study and a waiver from the Director of the Ministry of Environment. A discharge to a wetland has not been considered in our analyses at this time however may be considered at the direction of the Committee.

The MWR and previous liquid waste management plan amendments further regulate the quality of effluent with respect to wet weather flows, as tabulated below:

Effluent Criteria	Macaulay Outfall
Secondary	0 to 2 x ADWF
Primary	2 to 4 x ADWF
Screening (6 mm Ø)	> 4 x ADWF

ADWF = Average Dry Weather Flow

2.3.2 Ammonia and Toxicity

Ammonia and toxicity in wastewater effluent is a complicated topic which is discussed in detail in Appendix C. In summary, the Federal and BC governments have criteria that regulate the amount of ammonia in the effluent, in particular to the un-ionized ammonia concentrations. Our research and analysis concludes (Appendix C) that it is not necessary to reduce ammonia in the wastewater treatment plants to comply with both the federal and provincial regulations before discharging out the Clover and Macaulay outfalls. Enhanced treatment would be required however for any option that contemplates stream augmentation and/or wetland discharges.

2.3.3 Primary Liquid Effluent

The MWR requires primary effluent to meet:

$CBOD_5$ $\leq$ 130 mg/L

TSS $\leq$ 130 mg/L

2.3.4 Secondary Liquid Effluent plus Disinfection

Ocean outfall effluent criteria should best address both the federal and provincial regulations, as proposed in the table below, and based on the requirement of outfall diffusers at a minimum depth of 30 m below the surface.

Parameter	Units	Average Concentration	Maximum Concentration
$CBOD_5$	mg/L	$\leq$ 25	$\leq$ 45
TSS	mg/L	$\leq$ 25	$\leq$ 45
Un-ionized Ammonia in Effluent	mg/L	NA	$\leq$ 1.25 (1)
Un-Ionized Ammonia at End of Dilution Zone	mg/L	NA	$\leq$ 0.016 (1)
Total Residual Chlorine	mg/L	NA	$\leq$ 0.02
Faecal Coliforms	cfu/100 mL	NA	$\leq$ 200 (2)

(1) Only one of these parameters need to be met.

(2) It is our understanding that disinfection will be required. This is the standard concentration for discharge to recreational waters.

The frequency of testing and averaging period is dependent on flow rates as shown below for continuous flow systems.

Flow Range	Testing Frequency	Averaging Period
$\leq$ 2,500 m³/d	Monthly	Quarterly
> 2,500 but $\leq$ 17,500 m³/d	Every 2 Weeks	Quarterly
> 17,500 but $\leq$ 50,000 m³/d	Weekly	Monthly
> 50,000 m³/d	3 Days/Week	Monthly

2.3.5 Enhanced Tertiary Liquid Effluent

Secondary liquid effluent treatment with added disinfection is considered the base case level of service. However, in order to provide the ability for reuse we have identified enhanced tertiary treatment targets to satisfy most reclaimed water applications in the *Indirect Potable Water Reuse* category. This approach allows for aquifer recharge which is being contemplated in Colwood, and would require the following effluent criteria as defined in the Municipal Wastewater Regulation, as noted below:

Parameter	Indirect Potable Reuse	Monitoring Requirements
pH	6.5 to 9	Site Specific
$CBOD_5$	$\leq$ 5 mg/L	Weekly
TSS	$\leq$ 5 mg/L	Weekly
Turbidity	Maximum 1 NTU	Continuous Monitoring
Faecal Coliform (1)	Median <1 cfu/100 mL	Daily

(1) Median is based on the last 5 results.

2.3.6 Emerging Contaminants

There are in the order of 1,700 pharmaceuticals and personal care products (PPCPs) in wastewater, with some contaminants posing greater concern than others. At the present time, there are no published standards in Canada for the discharge of emerging contaminants to marine waters. Data has been collected by the CRD to estimate removal efficiencies of key contaminants at their Ganges membrane bioreactor (MBR) plant and Saanich Peninsula secondary plant (conventional activated sludge). Preliminary results show that approximately 80% of the contaminants (211 of 266) had removal efficiencies > 90% for the MBR plant. Approximately 45% of the monitored contaminants (145 of 324) had removal efficiencies > 90% for the activated sludge plant.

Increasing treatment levels beyond the regulations can be seen as an enhanced level of service. In order to allow for ongoing discussion and debate amongst the Committee(s) and the public, it is important that option sets provide for a range of treated effluent quality levels. Whether secondary and disinfection, or MBR, many emerging contaminants will be reduced during treatment significantly. While we have not included specific technologies to further reduce emerging contaminants, explicit criteria can be added as a required outcome for any proposals by the private sector.

Also note that treatment processes and technologies can be assessed further when the Ministry of Environment considers enhanced regulations for emerging contaminants. The CRD may also elect to expand their existing emerging contaminants monitoring program to research any new facilities in the Core Area in the early years of operation and to assess the level of reduction of emerging contaminants already occurring in the effluent. Space could be left in the plant(s) if it was desired for emerging contaminant treatment in the future once the specific effluent criteria are known.

2.3.7 Liquid Treatment Summary

While water reuse markets will be explored, any excess treated effluent has been designed to meet secondary treatment plus disinfection standards for all ocean discharges up to 2 x ADWF. Flows greater 2xADWF but less than 4xADWF will undergo primary treatment at the plant closest to the Macaulay Outfall. Water for reclaimed purposes will be treated to Indirect Potable Reuse Tertiary Standards given the water quality requirements for anticipated uses.

3.0 Options for Management of Residual Solids

The options available to manage residual solids along with the advantages and disadvantages of all legal methods of reusing or disposing of biosolids acceptable to the BC Ministry of Environment are fully detailed in a memorandum included in Appendix D. Section 3.0 provides for a summary of the memorandum.

Westside communities are currently assessing options for the management of local sanitary sewage. Research to date summarizes the management approaches available for the residual solids as well as an inventory of acceptable methods of reuse and disposal including their regulatory considerations and treatment approaches. There are a variety of different words which can be used for the residual solids which are produced during municipal wastewater treatment. For the purpose of this memorandum, the use of the word "sludge" will relate to the untreated residual solids which are produced during wastewater treatment and the use of the word "biosolids" will relate to sludge which has undergone treatment and meets the regulatory standards outlined in the BC Organic Matter Recycling Regulation (OMRR).

The CRD does not want biosolids or sludge going into the Hartland Landfill. It is our understanding that the Saainch Peninsula plant is discharging their solids into the landfill only until this process implements a solids treatment plant that they can utilize. Markets for solids byproducts must be developed as part of any Core Area solution.

Application to land is long-practiced and well documented, but often receives significant opposition, despite well-known benefits to plant growth and soil conditions. Treatment requirements can be costly, with little to no return on the capital and operational costs through sales opportunities. No authorisation is needed from the BC Ministry of Environment, but there is the need to register biosolids activities under the OMRR, e.g. a compost operation or a Land Application Plan. A policy statement was passed by the CRD Board indicating the desire not to apply biosolids to land.

Incineration and gasification are two available options to convert organics into energy. Globally, the common approach to using sludge as an energy source is an incineration-type process. However, incineration results in high capital and operational costs, which could include the need to dry the sludge before combustion in order to increase process efficiency. There are risks associated with the gasification process as well, as this approach is relatively new for sludge/biosolids management and, as such, there is little information on the long-term operation. Moisture content and calorific value are both important when considering process efficiency. There is a risk with respect to the authorisation requirements, until incineration and gasification of sludge/biosolids becomes established in BC. From the information available, it is expected that no authorisation is needed from the BC Ministry of Environment for the development of a combustion process for sludge/biosolids. Depending on the management approach for the waste solids and any wastewater which may be produced as a result of combustion, it is possible that no further authorisations are needed from the BC Ministry of Environment, with the only authorisation being a permit for air emissions. There is also a risk with respect to the requirement of a BC environmental assessment, although this may be avoided, depending on interpretations regarding the material for combustion and wording in the approved CRD Liquid Waste Management Plan. Clarification on these interpretations would be required from the BC Environmental Assessment Office.

In terms of the criteria to use for treatment technologies and management of solids, the following aspects have been used:

- The CRD has a policy that does not allow the land application of biosolids within its boundaries.
- The CRD strongly discourages solids being discharged to their landfill.
- Where it is economical, implement resource recovery.
- Consider the potential to integrate other waste streams.

4.0 Resource Recovery Opportunities Characterization Methodology

4.1 Introduction

Recovery of resources available in both the liquids and solids is highly dependent on the market conditions, energy prices, carbon and renewable credit markets and the overall cost for the projects. The following list identifies the resources present in the sewage and the sewage solids that will be considered as resources for recovery. Water recycling through purple pipe, recharge, indirect potable reuse, direct potable reuse and other reclamation alternatives are discussed later in this section.

Liquid

1. Thermal: Thermal energy recovery from sensible heat contained in the sewage in the form of hotter temperature (then ambient/winter condition) and cooler temperature (than ambient/summer condition).
2. Mechanical: Mechanical energy recovery from the transformation of potential energy into kinetic energy. This type of energy recovery is possible when water has a natural drop in elevation that can be harnessed and converted into energy.

Solids

1. Nutrients: Ammonia and Phosphorus recovery from the sewage solids.
2. Energy: The thermal conversion of the carbon contained in the sewage solids.
3. Bio plastics: The conversion or refinement of bioplastics from the sewage solids.
4. Organic Soil Amendment: The use of treated sewage solids to offset the use of commercial fertilizers
5. BioMethane: The biological conversion of carbon in the sewage solids to a usable gas through anaerobic digestion
6. Biofuels: The conversion of the sewage solids into usable vehicle fuels.
7. Carbon Dioxide: The capture, purification and compression of combustion and digestion by products to produce a commercial pure gas.

In addition to the ones identified, there are research level efforts to try and recover heavy and precious metals, and other high value organics. Since these are at a research level only at this time, they are not being considered for the evaluation.

As the resource recovery must compete with the products they are offsetting, it is extremely hard for this effort to adequately evaluate the revenue source that could be derived from implementing any of these approaches. In other words, market commodity prices are dynamic and cash flow analysis is subject to multiple caveats and risks. As such we propose the CRD work with the private sector to distribute risk appropriately in an effort to identify and fund the recovery of the resources available in the sewage. A common and well-regarded approach is to issue a Request for Statements of Interest (RFSI). This document would be issued to the general private market to propose on resource recovery opportunities with their technologies and provide the CRD with an all-in cost to install the technology, receive (solids or liquid) the product, process it and provide a higher value material as well as the recovered materials extracted from the product.

The CRD can then evaluate these proposals and rank them based on their:

1. Alignment with CRD Goals and Objectives
2. Environmental Benefit
3. Cost
4. Risk to CRD and member Cities.

Through this process, the CRD will make sure that the market is driving the recovery of resources and how much investment the CRD is willing to introduce to promote the recovery of resources that with today's utility costs may require longer term investments.

4.2 Water Reuse

4.2.1 Water Reuse Target Market Summary

When treated to a high enough standard, treated effluent can be reused instead of potable water. A target market framework helps to navigate the multiple possibilities for reuse to select applications that have greatest potential. Water recovery target markets should deliver on the following key themes:

- Demonstrate long-term demands and revenues
- Support community amenities
- Reduce the scope of infrastructure needs
- Demonstrate synergy with conventional public utility services

For Westside Solutions, supply-demands studies centered on water applications that require less than potable-quality water in addition to water demands situated in clusters which helps to reduce the cost of additional pipes to convey flows. Ideally, treated effluent on the Westside should include:

- large tracts of irrigable land such as parks and green spaces;
- significant industrial water reuse such as greenhouses or manufacturing operations;
- growth centers where new developments can be encouraged to include additional plumbing systems for toilet flushing or outdoor irrigation; and
- environmental augmentation.

These types of customers typically present the lowest capital cost for system set up (so long as they are located near treatment facilities), provide long-term demands and revenues, support community amenities such as parks and growth and generally conforms to the type of water services provided today.

Spatial analysis based on land use uncovers target markets and illustrate clusters of high demand. Each land parcel is coded based on its land use through the BC Assessment Authority which provides a proxy for water use potential i.e. parks, institutional-vacant, dairy farm, etc. At a conceptual level, these land use codes provide a basis for the potential for land application in Westside communities. Further, local Official Community Plans, land use plans and regional growth centers illustrate where focused, dense development may occur over the next 20+ years. The cost of retrofitting (re-plumbing) existing buildings to allow for treated effluent reuse is prohibitive; it is more feasible to include non-potable water lines in new construction and to phase in non-potable sources over time. Combined, land application and regional growth centers provide for lower-barrier methods for reuse.

Environmental augmentation includes directing treated effluent to natural water courses for beneficial reuse. While these methods don't typically provide revenues, they represent an opportunity to close the wastewater loop and restore water supplies locally, in urban areas; particularly where/when there is demonstrated need. Typical forms of environmental augmentation include:

- Direct augmentation to streams, rivers or other surface water bodies,
- Indirect augmentation to surface water bodies which includes infiltration to adjacent soils allowing flows to meander into the substrate groundwater or into actual surface flows,
- Aquifer recharge, and
- Wetland enhancement.

Each of these methods requires adequate environmental study to determine the feasibility including risks associated with any option. Water bodies which demonstrate supply issues are typically studied for stream augmentation because there is a clearer link to beneficial reuse, instead of simply becoming a vector for disposal. Wetlands throughout the Westside have not been studied to date.

Colwood has studied the potential for indirect augmentation via aquifer recharge for the highly permeable soils near royal Roads University and further west toward Langford. Local infiltration rates are relatively high and may provide for aquifer recharge for 10 to 30 MLD, based on recent reports. If approved by the Director (of the Ministry), this approach could negate the need for an alternate disposal method such as local outfall to the ocean, however we have assumed any effluent that does not meet the specifications would be discharged into the CRD trunk to be treated by a downstream plant. Westside Technical Staff are awaiting formal feedback from the Ministry regarding the potential for aquifer recharge including any waiving of outfall infrastructure. Option sets which include a treatment facility in Colwood take into account the preliminary feasibility results for aquifer recharge.

4.2.2 Summary of Water Reuse across the Westside

Table 4.1 summarizes the land application; toilet flushing and aquifer recharge possibilities on the Westside based on the applied target-market framework and analysis methodology. It is important to note that while estimates can be developed per municipality, it became clear during analysis and mapping that demands were clustered near growth centers of Colwood-Langford and separately, in Esquimalt (with some overlap to View Royal). Establishing two reuse systems provides for 3/4 coverage of the treated effluent target possibilities and also reduces the need for redundant infrastructure.

Table 4.1 – Reuse Target Market Scan

Node	Colwood-Langford	Esquimalt
Area (ha) w/ Irrigation Potential	275	115
Demand (low) (cm/year)	45	30
Demand (high) (cm/year)	60	45
Volume (low) (ML/year)	1,240	340
Volume (high) (ML/year)	1,650	520
Aquifer Recharge (ML/year)	3,430	n/a
Toilet (2030; ML/year)	1,780	435

Additional lands in the View Royal-Highlands interface could provide greater irrigation potential however these lands would require significantly larger reuse systems. Further, Colwood continues to undertake more detailed water reuse analysis. Table 4.1 should be updated for future analysis as the results of Colwood's analysis are available.

Overall, if the Ministry accepts Colwood's aquifer strategy then the Colwood plant could demonstrate near 100% reuse of flows in that area: during the winter when there is less need for irrigation, reuse can be focused toward aquifer recharge and toilet flushing, whereas during irrigation seasons, aquifer recharge could be reduced significantly while flows are redirected to land application. It is also feasible to phase-in greater effluent reuse capacity at the Colwood facility as population growth occurs in Colwood-Langford.

Future phases of analysis should confirm with the Ministry whether redundant capacity is needed at alternate plants on the Westside to account for any potential treatment upsets at the Colwood facility. This would provide greater assurance of environmental protection through planned and unplanned treatment disruptions.

4.2.3 Water Reuse Infrastructure Systems

Treated effluent systems require their own, separate infrastructure for distribution. Each proposed wastewater treatment facility would include a pumping station to cover the range of elevations and flows as well as distribution pipes based on conceptual routes. In order to avoid the costs and footprint of equalization storage, reuse of treated effluent would be limited to the daily capacity of the plant. This strategy does not significantly limit the supplies available for irrigation or toilet flushing.

For Colwood-Langford, the conceptual reuse system includes approximately 19,500 meters of reuse pipe and a pumping system equivalent to the average daily capacity of the plant. The Esquimalt system includes almost 17,000 meters of reuse pipe and pumping system that can deliver the peak irrigation and toilet flushing demands in 2045. While the reuse systems are similar in scope, the Colwood-Langford plant provides 5x (or greater) the amount of reuse potential because of the land irrigation demand and aquifer recharge, providing a significantly greater return on investment. In effect, while the 4-plant option set would provide higher level of service and boost enhanced tertiary water quality, it may not provide greater reuse opportunities for a long time.

5.0 Technology Needs and Considerations

5.1 Representative Sites and Characteristics

Representative design is a helpful approach to assessing the relative merits of multiple option sets, each with their own feasible sites. For Westside analysis, representative design was customized to suit myriad possible configurations by identifying four types of treatment plants to suit the flow design scenarios across the municipalities. Table 5.1 summarizes the four types of plants that would be situated across the Westside as they relate to each option set.

Table 5.1 - Site Characterization Summary

Site Characterization	Neighbouring Land Use	Flow Range (Average Dry Weather Flow)	Anticipated Plant Purpose – Liquid Train
Small Distributed	Residential	< 5 ML/day	Tertiary treatment for local reuse
Medium Distributed	Residential	6-15 ML/day	Tertiary treatment for local reuse
Large Distributed	Residential	16 – 25 ML/day	Tertiary treatment for local reuse
Extra Large Distributed or Central	Non-Residential	26 + ML/day	Primary & Secondary treatment for outfall and tertiary treatment for local reuse

5.2 Liquid Treatment Options and Representative Designs

The small, medium and large plants are part of distributed option sets whereby plants may be located in residential areas. It is our understanding, based on the public process to date, that the primary reason to have a distributed system is to put plants near target markets for resource recovery thereby signalling the need for tertiary level treatment. The driver for smaller footprint and consideration to 'neighborhood fit', treatment technologies should be selected that occupy a relatively smaller physical space.

Representative design includes technology selections on a provisional basis: at this stage, design choices provide key insights into the possibilities at each plant without eliminating the innovation from the private sector to propose the ultimate solutions. Indeed, the selection of specific technologies and manufacturers is a complicated process and ought to consider, more detailed evaluations such as:

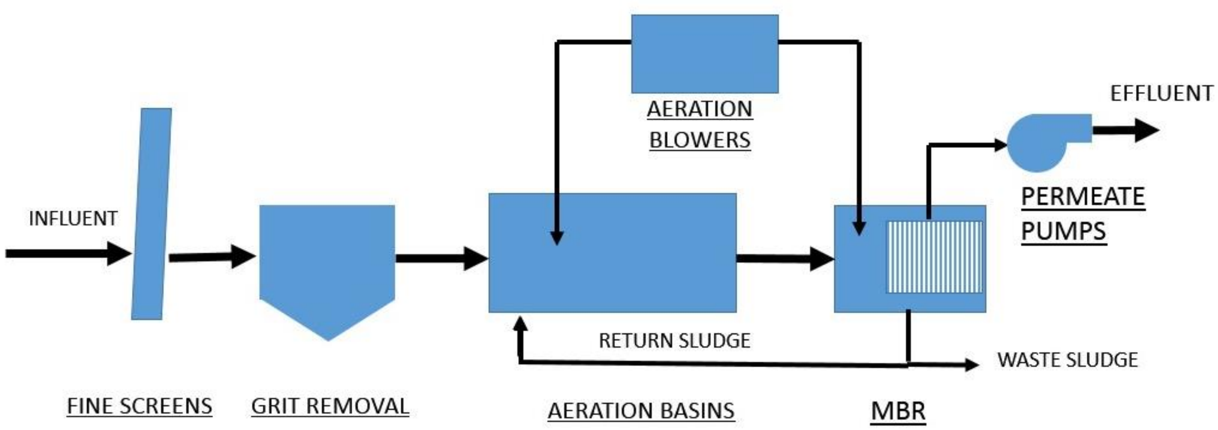
1. Method of procurement
2. Competition amongst a reasonable number of manufacturers

3. Financial security of manufacturer
4. Proven in the market place
5. Life cycle costing (capital and operating)
6. Flexibility
7. Ability to phase construction
8. Carbon footprint
9. Operational complexity
10. Physical area requirements
11. Amount of commonality with equipment desired within the entire CRD

Examples of tertiary technologies that demonstrate potential for the Westside include: membrane bioreactors, sequencing batch reactors with ultrafiltration membranes, moving bed bioreactors with ultrafiltration membranes and continuous flow intermittent cleaning with ceramic membranes. Representative designs for the small, medium and large plants include membrane bioreactor (MBR) processes because it is well-known to tertiary quality requirements, because there is competition among the manufacturers of the technology, and also, because it occupies a small physical footprint. .

A typical generic MBR plant would include grit removal, fine screens, anoxic and aerated bioreactors, membranes, a waste sludge wasting system and ultraviolet light for primary disinfection with sodium hypochlorite for secondary disinfection (chlorine residual). Odour control facilities would also be provided. A typical process schematic for an MBR process is shown in Figure 5.1 below.

Figure 5.1 – Membrane Bioreactor (MBR)



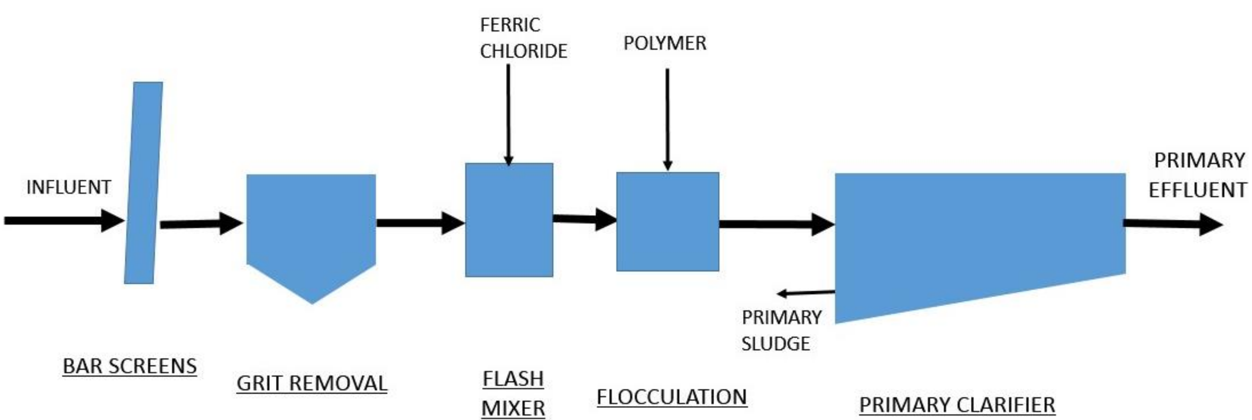
Each of these plants would extract 2 x ADWF from the CRD trunk sewers. Any wet weather flows above this amount will be left in the trunk sewer to be treated at the extra-large distributed or central plants.

The extra-large distributed or central plants located in non-residential areas are primarily targeting to meet the federal and provincial regulations. This means meeting the secondary level of treatment and processing the 2 to 4 x ADWF to a primary treatment level. The intent with these plants is to ensure there is sufficient site area to allow for a side stream of flow to be treated to a tertiary level to satisfy the target resource recovery markets in the reuse areas identified nearby the plant. However, it is recognized that because the demand for reuse in the vicinity may be a small fraction of the treatments plants capacity, these facilities will operate at reduced capacities much of the time. Private sector responses allow for other technologies that meet or exceed the level of treatment identified above.

Primary treatment technologies are diverse as well and technologies considered for this project include traditional primary clarification (PC), ballasted flocculation (BF) and chemically enhanced primary treatment (CEPT). The mechanical fine mesh screen systems were reviewed, but were eliminated for further consideration since they do not consistently achieve the $CBOD_5$ < 130 mg/L requirement.

Representative design analysis includes the CEPT process because it is established in the market, occupies a relatively small physical footprint and provides a high level of reliability. The CEPT process includes chemical addition, mechanical mixing and primary clarifiers with sludge removal pumps. The primary clarifiers would be covered and include odour removal equipment. Figure 5.2 provides a schematic of a CEPT system with a headworks that includes screens and grit removal.

Figure 5.2 – Chemically Enhanced Primary Treatment (CEPT)



Representative design for extra-large treatment facilities included review of processes that were suited for providing secondary treatment to larger flow ranges. Suitable technologies include conventional activated sludge (CAS), moving bed bioreactors (MBBR) and integrated fixed-film activated sludge (IFAS). Process schematics of CAS, MBBR and IFAS are provided in Figures 5.3, 5.4 and 5.5 below.

Figure 5.3 – Conventional Activated Sludge (CAS)

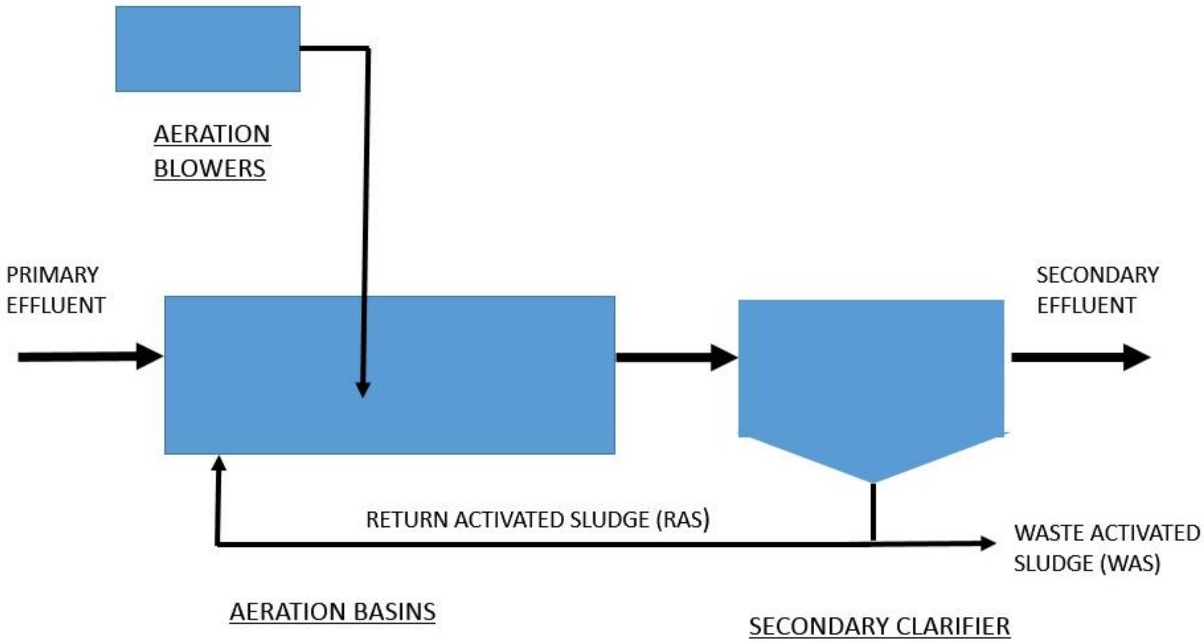


Figure 5.4 – Moving Bed Biological Reactors (MBBR)

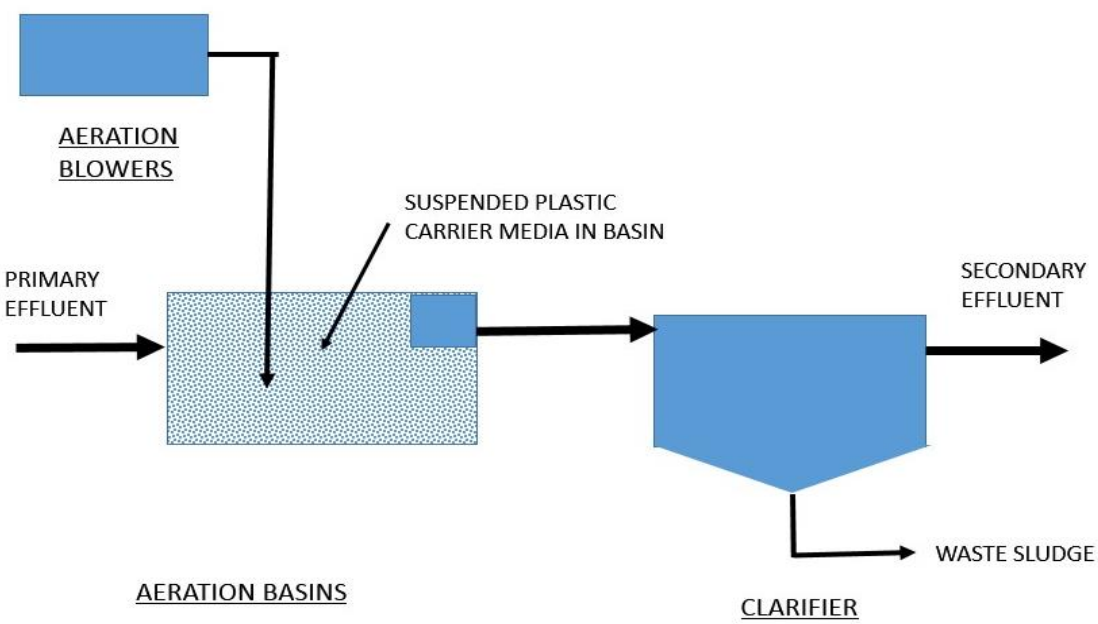
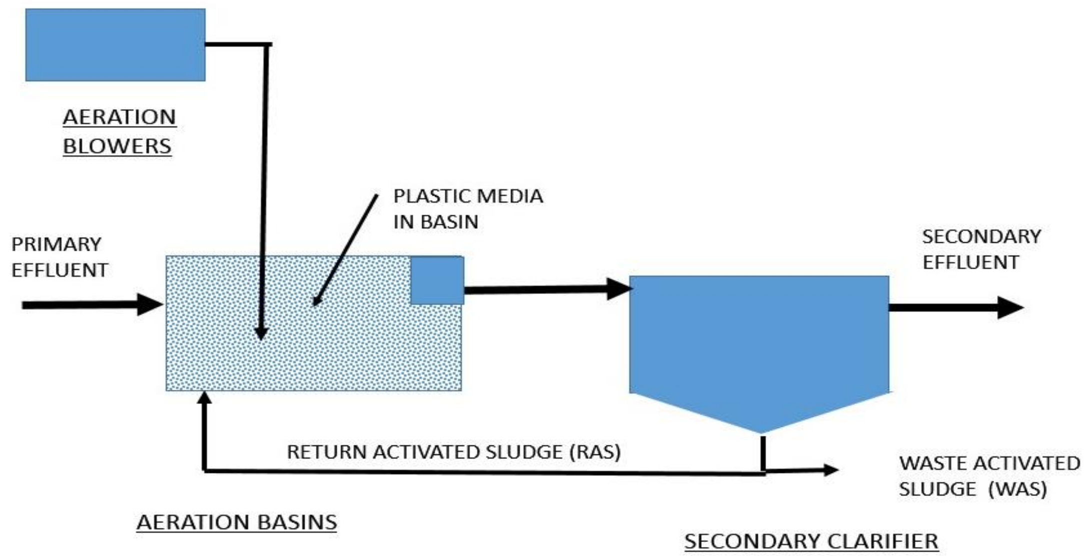


Figure 5.5 – Integrated Fixed-Film Activated Sludge (IFAS)



The MBBR and IFAS systems processes are similar to CAS, in that they both typically use aeration and clarification tanks for treatment. One advantage of these processes is that they reduce the size of aeration tanks needed for biological treatment. This is accomplished by adding media (plastic pieces, ropes, or sponges) to the aeration tanks. Bacteria grow on the surface of the media in a "fixed film," and effectively increase the amount of bacteria that can be held within a given tank size. Both the IFAS and MBBR processes provide a fixed media with an aeration basin. IFAS differs from MBBR in that is more like the activated sludge process, since it provides for a return of activated sludge from the clarifier back to the aeration basin. These systems are sometimes used to upgrade an existing aeration basin in a treatment plant, by retrofitting existing aeration basins with the media to be able to provide increased capacity for the existing basin footprint.

The secondary treatment process for extra-large facilities includes primary treatment via CEPT followed by secondary treatment. The initial technology selected was CAS due to lower operating costs than the MBBR or IFAS systems. Based on the available land area for the selected sites, it became apparent that a secondary treatment process requiring a smaller footprint than a CAS system would provide advantages. An MBBR or IFAS system would require a reduced foot print, but annual operating costs would be greater than CAS because of less efficient aeration. These systems would provide an effluent quality that would meet or exceed the proposed discharge limits. Overall, the MBBR and IFAS processes were reviewed in order to meet the treatment limits but also reduce the footprint. Also note that the process would typically include grit removal, screens, primary treatment, and an aerated tank with a floating or fixed film media. Any floated media systems require screens to contain the media in the tank, in addition to a clarification system, a waste sludge system, and ultraviolet light for primary disinfection. The aeration basins would be covered and include odour control equipment.

5.3 Solids Treatment Options and Representative Designs

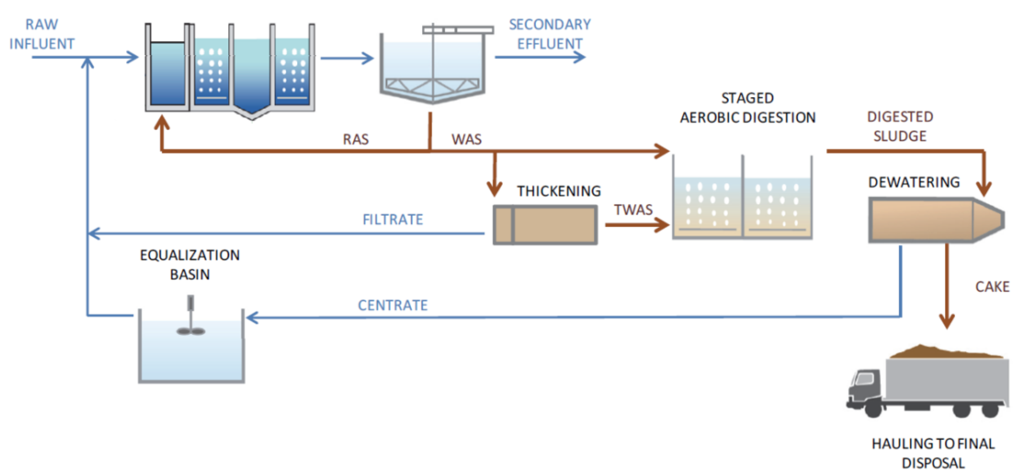
Solids treatment alternatives are narrowed based largely on these local boundary conditions:

1. The land application of any sewage solids is not allowed. This includes highly processed forms like pelletized solids, biochar or solids converted through thermochemical methods. New markets must be developed through partnerships to reflect the value of the byproduct in an effort to offset the treatment and development costs.
2. The landfilling of sewage solids is strongly discouraged by the CRD. Under extraordinary circumstances, the landfill may accept sewage solids at a cost of $121 dollars per wet tonne.
3. The CRD is considering an integrated waste resource plant that may include sewage solids in addition to select yard, garden and kitchen waste managed in an integrated manner with solid waste management services.

In addition to these boundary conditions, Phase 2 analysis for Westside includes review of three key technologies for the stabilization and treatment of the sewage solids generated at the liquid treatment plants: aerobic digestion, anaerobic digestion and gasification.

Aerobic Digestion: Through this process, the collected sewage solids are kept under aeration for a period of no less than 28 days (using reactors in series) at a concentration of less than 2% solids (to maintain adequate air transfer and avoid odors and anaerobic conditions). The resulting is a wet-soil like material with high potential for odors, bacterial regrowth and additional degradation. This process is energy intensive and can be capital intensive in larger applications. Figure 5.6 shows a generic flow schematic for the aerobic digestion alternative.

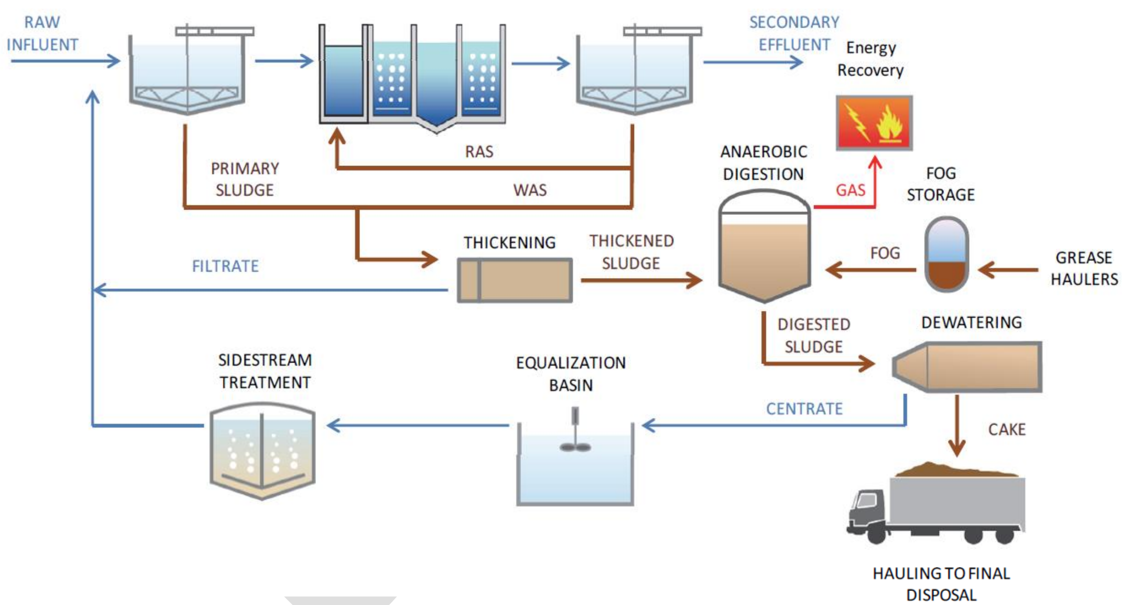
Figure 5.6 – Aerobic Digestion



1. Anaerobic digestion: Through this process, the collected sewage solids are kept under anaerobic (no oxygen) conditions for a period of 15-25 days at a concentration of at least 4% solids to allow the microorganisms to consume the organic matter efficiently and produce a valuable resource in the form of methane gas that can be recovered and reused. These systems produce a wet-soil like material with moderate potential for odors, bacterial regrowth and additional degradation. This process generates energy and is cost effective, compared to aerobic digestion, in facilities larger than 20 ML/d. Anaerobic digestion is particularly suited for facilities that have primary clarification as the performance of the system is far superior to the anaerobic digestion of biological sludge (Waste Activated Sludge).

   Figure 5.7 shows the generic process flow diagram for the anaerobic digestion alternative including energy recovery and fats oils and grease digestion to supplement gas production.

Figure 5.7 – Anaerobic Digestion



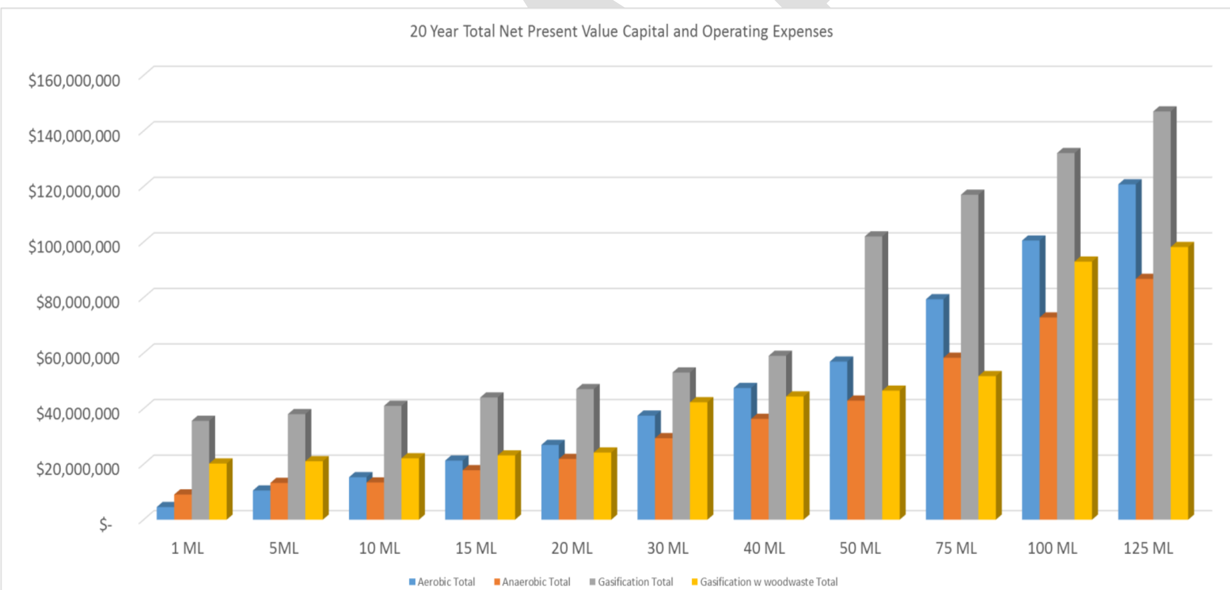
2. Gasification: This process is a thermal process that converts part of the organic carbon in the sewage solids into a syngas through non-biological processes. Unlike the previous approaches, this approach will require the participation of a technology manufacturer as the gasification systems require proprietary technology. The end product of the gasification technology is a biochar that does not look like a soil material. It has the composition and physical properties of activated carbon but is irregular and may produce dust. This technology struggles to achieve energy neutrality using only sewage solids; it requires a solids concentration of approximately 80% to become energy positive; manufacturers of gasification technology claim that the use of other feedstocks, like wood waste or yard, garden and kitchen scraps make the process energy positive.

While liquids and solids treatment processes overlap and link together, it's typical to assess solids recovery methods in an isolated manner to illustrate the cost and revenue conditions for each approach. Solids recovery scenarios for Westside analysis include:

1. Provide full level of solids treatment at each site.
2. Reintroduce the solids into the sewer system for treatment at the peak weather facility
3. Provide solids dewatering and transport at the smaller facilities and full treatment at the peak weather facility.

Figure 5.8 shows the 20 year total net present value (NPV) for the solids alternatives as a function of the plant size.

Figure 5.8 – 20 Year Total Net Present Value Capital and Operating Expenses



Takeaways and detailed insights from Table 5.2 and Figure 5.8 include:

1. Gasification of sewage solids without additional feedstocks is not cost effective in a 20 year life cycle. Based on the cost estimating, the reduction in mass obtained by drying and gasifying the sewage solids is significant and reduces the cost of disposal. This offset however does not pay back for the cost of the initial installation and the cost of the natural gas to drive the drying process.
2. Gasification with feedstock is cost effective in a 20 year life cycle. The overall costs are similar to anaerobic digestion (assuming a market can be created at a cost less than $121/tonne).

3. Based on the size of the distributed system facilities, all of the smaller facilities would incorporate aerobic digestion, as the minimum facility size that provides a NPV benefit utilizing anaerobic digestion is around 20 ML average daily flows. Because the option sets still provide for the peak flows (>2X ADWF) to be routed to a peak flow "large facility", the system will have all of the costs of the smaller plants plus a large fraction of the costs of the single facility. Therefore the cost of providing full solids treatment at each of the satellite facilities is approximately $25,000,000. These costs do not appreciably offset any costs for the larger facility. Based on this analysis, it is recommended that the CRD consider only solids dewatering at the satellite facilities. This approach will provide for a reduction in the cost of almost $20,000,000 as the solids dewatering systems would remain at each of the satellite plants and a solids receiving station would be required at the large plant.
4. Based on preliminary net-present value analysis, the use of anaerobic digestion at the large plant with trucking of the solids from the satellite plants and gasification using a yard waste feedstock are comparable. A Request for Statements of Interest and Request for Proposals will assist the CRD in confirming reliable, financially-backed solutions for solids recovery management.

5.4 Energy Recovery Options and Representative Designs

Until further research can be conducted on the full life-cycle costing of gasification including integration of waste streams, anaerobic digestion was included for life-cycle costing due to its energy positive balance and more reliable cost estimates (because there are more installations for comparison).

The industry standard for Energy recovery from anaerobic digesters is to provide the ability to use a combined heat and power (CHP) system for the facility. CHP units utilize either an internal combustion engine or turbine to generate power; the waste heat from these units is captured and used to provide heat for the digesters.

Newer approaches include the refinement of the biogas to Biomethane by processing the gas to higher standards and removing the carbon dioxide present in the gas. This biomethane can be compressed and used to fuel CNG vehicles if there is sufficient production and the demand (buses or trash trucks) are located in close proximity where the gas is being produced. As this approach requires additional treatment and the marketing of the gas, this recovery alternative is a candidate for a public-private-partnership. We recommend that the CRD issue a RFSI similar to the resource recovery RFSI for the inclusion of private market capital to promote and produce biomethane.

Therefore, the Energy Recovery Option will be limited to the sites that can support anaerobic digestion and will focus on the use of a CHP system (micro-turbine or internal combustion generator) to match the expected average gas production.

Technology	Electricity Produced	Heat Recovered
 MICROTURBINE	30%	30%
 INTERNAL COMBUSTION GENERATOR	35%	35%

Based on the size of the facility it is recommended that an internal combustion engine be evaluated as the CHP driver. The table below shows the estimated cost of the combined heat and power system for the central facility.

Type of CHP	Size of Installation	Cost of Installation	Power Generated	Heat Rejected to Recovery
Internal Combustion Engine	1.5 MW	$7,750,000	1,285 kW	4 MMBTU/hr. 16,000 Kcal/hr.

6.0 Costing Factors

6.1 Introduction

Costs will be presented in 2015 Canadian dollars. It is important to recognize that since 2010, and from 2015 until the systems are constructed, prices of all cost elements can be significantly affected by time and other cost escalations. For example, the Engineering News Record (ENR) is an industry guide to the construction industry. The ENR states that the construction cost index for Toronto (BC is currently not represented in the ENR) has increased from 9,434 (2010) to 10,515 (2015). This is equivalent to a construction cost increase of 11.5% over the 5 year period. A review of data available from Stats Canada for the Victoria area indicates that their construction price index has risen from 111.5 (2010) to 122.8 (2014; no 2015 data yet available), using a base index of 100 (2007). This is equivalent to a 10.1 % increase over this 4 year period. This would appear to correlate fairly closely with the 11.5 % increase over 5 years for the ENR index. We have used the Stats Canada index for the purposes of calculating all cost escalations.

The impact of the exchange rate between the Euro, the US and Canadian dollars is also relevant, since a portion of the equipment may be manufactured in the USA or Europe.

Some costing considerations are difficult to predict, like the supply and demand and productivity of skilled labour in the Greater Victoria area, especially if other large scale projects in the province were to occur, such as liquefied natural gas and the Metro Vancouver Lion's Gate WWTP. It is also widely known that construction on Vancouver Island carries a premium compared to the mainland.

Cost estimates will also stem from recent engineering and costing experiences for construction projects supported by Urban Systems and Carollo, both locally and abroad. Cost estimates conducted by other consultants for CRD have been reviewed and informed the updated unit rates.

6.2 Capital Cost Breakdown

Capital cost estimates include multiple factors and contingencies. For Class D cost estimates we have included *general requirements*, *contractor profit and overhead*, *construction and project contingencies, engineering, administration, interim financing and escalation.* Table 6.1 illustrates these cost factors for an example project with a base construction cost estimate of $1,000,000. For comparative purposes the percentages used in this study are the same as those used in previous studies. We have assumed the mid-point of construction is four years or 2019.

Table 6.1 - Capital Cost Breakdown

Description	Total
Construction Cost	$ 1,000,000
General Requirements (Mobilization, Demobilization, Bonds, Insurance, etc.) – 10%	$ 100,000
Contractor Profit/Overhead – 10%	$ 100,000
Construction/Project Contingency – 35%	$ 350,000
Subtotal of Direct Costs	**$ 1,550,000**
Engineering – 15%	$ 233,000
CRD Administration and Project Management and Miscellaneous – 8%	$ 124,000
Interim Financing and Inflation During Project – 4%	$ 62,000
Escalation to Mid-Point of Construction – 2%/year (compounded over 4 years)	$ 124,000
Total Capital Project Cost	**$ 2,093,000**

6.3 Pump Stations

The pump stations that will be used to pump effluent from the existing CRD collection system to the proposed treatment plants are typically designed to be low-lift, high-volume facilities. Because of the unique nature of each pump station (siting, access, pump capacity, proximity to major utilities and sensitive areas, geotechnical considerations, etc.), costs for such facilities can vary widely.

Class D cost estimates (-15%/+25%) are commonly derived from cost curves which are based on extensive cost data gathered from the combination of a wide range of pump stations throughout the industry. These curves typically plot station costs against the size of the stations in L/s. Typical curves are shown in Appendix E and were developed by an extensive study undertaken 11 years ago for the Ministry of Public Infrastructure Renewal in Ontario. In conducting our estimates we assessed the application of estimates from Ontario against our experience in the BC market. The unit rates have been multiplied by 1.6 with consideration of the following:

a. 20% - for temporary and permanent site work.
b. 20% - for standby power and SCADA
c. 20% - inflation from 2004 to 2015.

Where possible, the unit rates have been compared to cost data available from recently designed and constructed projects, to confirm general data conformance. These facilities typically comprise a concrete below grade wet well, in which the sewage is collected and from which the sewage is pumped using submersible pumps. An at-grade superstructure (usually concrete block or similar durable material) is located on top of the wet well (typically poured in place concrete), to house mechanical and electrical equipment, including MCCs, PLCs and standby power.

Where pump stations will be included in the design and construction of a wastewater treatment plant, i.e., are <u>not</u> stand alone facilities, experience informs that a 30% cost deduct should be applied to the unit costs rates to account for common infrastructure and other facility synergies.

Below is a summary of a few examples of anticipated pump station costs, based upon the curves in Appendix E and including the 1.6 multiplier. All rates are in 2015 dollars and pertain only to the Construction Cost portion as outlined in Section 6.2, which would be factored up as per Table 6.1.

Pump Station Size	Construction Cost (CDN$)
350 L/s	$ 3,400,000
750 L/s	$ 6,400,000
925 L/s	$ 8,000,000

The Craigflower Pump Station upgrade tendered price not including GST was $11,000,000 and the capacity is approximately 1,000 L/s. This value aligns quite well with the Ontario curves given that this number includes contractor profit/overhead and general requirements and was constructed in the last two years.

6.4 Piping

The piping systems that will be used to service the Core Area option sets will comprise PVC pipe installed in existing rights-of-ways, typically existing road allowances. As such, the unit cost rates allow for pavement and any existing surface improvement restoration. In addition, an allowance has been included for temporary site works, traffic control and associated above ground work.

In general, these pipes will provide the connectivity between the existing CRD sewer trunk mains, proposed pump stations, proposed wastewater treatment plants and proposed outfalls. Typically sanitary collection systems are designed for minimum flow velocities of 0.8 m/sec to ensure that material does not build up within the piping systems. From a capital cost and energy perspective, ideally flows should be near 2.5 m/sec. Given the wide range in flows within the CRD system (0 to 4 x ADWF), detailed analysis is required for any pumped and piped system to ensure that the optimum life cycle range of costs are achieved.

For the purposes of this costing exercise, we have sized our pipes such that the resultant velocities are in the 1.5 to 2.5 m/sec range, based upon 2 x ADWF.

The unit cost rates developed are based upon meeting or exceeding accepted industry design standards, such as those detailed by AWWA.

The following is a summary of the unit cost rates developed by Urban Systems as part of the ongoing work with the CRD. All rates are in 2015 CDN dollars and pertain only to the Construction Cost portion outlined in Section 6.2.

Pipe Diameter (mm)	Construction Unit Cost $/m
300	$ 700
350	$ 740
400	$ 780
450	$ 820
500	$ 870
600	$ 950
750	$ 1,130
900	$ 1,350
1050	$ 1,620
1200	$ 1,850
1350	$ 2,100
1575	$ 2,450

6.5 Outfalls

Developing unit cost rates for outfalls into a marine environment proved to be the most challenging task, given the wide range of unknowns and variabilities. Not too dissimilar from pump stations and their unique features, the unit cost rates for outfalls also vary widely. In particular, geotechnical considerations and seabed profiles will have significant impacts on these costs. However, unlike, pump stations, there is not a large data base on which to draw upon and develop cost curves.

Outfalls are anticipated using steel pipes, installed with concrete collars and anchors. Based upon the data available, 2015 costs for these two sizes were developed as summarized below and pertain only to the Construction Cost portion outlined in Section 6.2.

Pipe Diameter (mm)	Construction Unit Cost $/m
600	$ 6,150
750	$ 7,000
900	$ 7,800
1050	$ 8,600
1200	$ 9,600
1350	$ 10,800

6.6 Methodology to Provide WWTP Cost Estimates

For Wastewater Treatment Plants the costing methodology is more complicated since each plant includes both liquids and solids treatment processes and costs are largely dependent on the indicative technology selected. For this project we will use the experience database developed by Carollo and Urban Systems in order to determine appropriate costs for the indicative facilities. Only the representative technology will be costed in order to arrive at comparative cost estimates between the option sets.

6.7 Revenue Sources

Revenue sources will cover the range of incomes based on exchange of goods or services and also monies that offset costs including potential development contributions or potential partnerships which minimize the extent and impact of new works. Phase II analysis for Westside does not include detailed life-cycle costing analysis including each of the following revenue examples, however these will be assessed further as part of Phase 2 for the Core Area:

- Utility billings, requisitions, transfers and interest gains
- Retail rates for resource recovery systems including water rates, gas/fuel rates (solids recovery) and incomes collected for any sales related to solids residuals
- Development cost charges and other potential private sector development contributions available to local governments
- Municipal cost-shares for example where infrastructure upgrades are needed for both local and regional benefit
- Grants in terms of secured monies available to Westside
- Other offsetting costs for example, homeowner cost savings that may arise through waste diversion as part of integrated solids recovery

Three important notes about revenues at this time include:

- Water revenues increase over time as irrigation customers are phased-in and as growth and development potentially incorporate recycled water for toilet flushing
- Energy recovery revenues are currently offset by costs associated with disposal of byproducts eliminating any addition revenues from wastewater solids; further analysis is required as part of Phase 2 analyses
- Carbon offsets are being studied so that they can be included, where appropriate

6.8 Operating and Life Cycle Cost Assumptions

Life-cycle costs will be prepared for each of the option sets. Life cycle costing includes capital, as well as operating costs and later, consideration to revenues as part of the aggregate financial scenarios. Operating costs will consider typical cost elements as well as revenue (outlined in Section 6.7) which can reasonably be assumed to accrue given the resource recovery opportunities available.

Below is a summary of the inputs into our life cycle costing model. As this is a constant dollar analysis, all costs will be in $2015. The only escalation that will be included will be 2% per year for initial capital projects for the time from today until midway through construction which is assumed to be 2019.

We propose to conduct sensitivity analysis on the discount rate, escalation factors and revenue projections to monetize the risks inherent in long-term capital financing and service delivery. As a base case, our life cycle analysis will be guided by previous analysis and in particular, will suit treasury board guidelines to suit the funding partners.

We will assume that chemical and energy costs will be linearly proportional to flow. For example, the current Langford flow is 5.2 MLD and 2030 design is 14.2 MLD. Electricity cost in year one will be:

$\frac{5.2}{14.2}$ x 100% of the 2030 design year.

Life Cycle:	15 years (2015-2030)
Interest Rate:	to be confirmed with funding partners (as needed) e.g. 4%
Inflation Rate:	to be confirmed with funding partners (as needed) e.g. 2%
Discount Rate:	to be confirmed with funding partners (as needed) e.g. 3%
Water Cost:	Distribution cost from distribution supplier (e.g., CRD for Westshore & Sooke) is \$1.81/m³
Electricity Cost:	Average rate \$0.08/kwh

Chemical Costs; Current market prices

Labour Rates:

Labour Type	2015 Annual Salary [1]
Plant Manager	$ 158,000
Chief Plant Operators	$ 135,000
Chief Area Operator	$ 113,000
Plant Operator	$ 90,000
Labourer	$ 56,000

[1] Including benefits and administration

Vehicle Rates: $40,000/yr./vehicle

Trucking Rates: Current market prices

Disposal Rates: Current tipping charges to CRD Landfill (i.e., $157 per tonne for screenings and pumpings from Sewage Treatment Plants and $121/tonne for waste sludge < 80% moisture)

Maintenance/Repairs Pump Stations: 1% of Capital/yr.

Equipment Replacement Reserve: 1% of Capital/yr.

Operation & Maintenance Contingency: 10% (includes testing, insurance, miscellaneous)

7.0 Description of Option Sets

7.1 Introduction

After discussions with the Westside Technical Committee it was agreed that the three option sets to be examined in more detail are:

Option 4A (Revised)	Langford/North Colwood/View Royal/Esquimalt First Nation
Option 1B	Esquimalt First Nation
Option 2C (Revised)	North Colwood/Esquimalt First Nation

The rationale for selecting these three option sets is as follows:

Four Plant Option

- Distributed model with each community contributing to a sub-regional solution.
- Increasing the opportunities for reuse of treated effluent and heat recovery since there are multiple plants.
- Increased potential for revenue from reuse/recovery options.

One Plant Option

- Single plant may be the most cost effective since it involves the least amount of new pipe and pump stations.
- Operations are consolidated in one location.

Two Plant Option

- This specific option takes advantage of all the reuse work that has been undertaken by Colwood.
- Does not require solids dewatering of treatment in Colwood, which simplifies that plant.
- The large plant becomes the “alternative method of disposal” required by the Ministry of Environment in the event of plant failure. As such a second ocean outfall is not required.

Note that all plants will have ultraviolet disinfection to achieve the required concentration of faecal coliforms, whether for secondary or tertiary plants. Since the demand for effluent reuse is not likely to be 100% of the capacity of any of the plants it is proposed that chlorination not be included in the plants. Rather, it is suggested that wherever the takeoff points are from the treated effluent line that chlorine be added there. This will ensure that any discharge to the ocean will not have a chlorine residual > 0.02 mg/L.

7.2 Site Prioritization

Site prioritization was conducted simultaneous to option set design and costing. Insights from sizing, infrastructure and resource recovery potential signal a pared-down list of sites, as detailed in Appendix F, and summarized here as:

- Site 2a Langford VMP and Meaford Avenue
- Site 11 Colwood Park and Ride
- Site 14 Colwood West Shore Parks and Recreation
- Site 15 Esquimalt First Nation
- Site 16 View Royal Burnside and Watkiss
- Site 17 Esquimalt Bullet Park Site 17

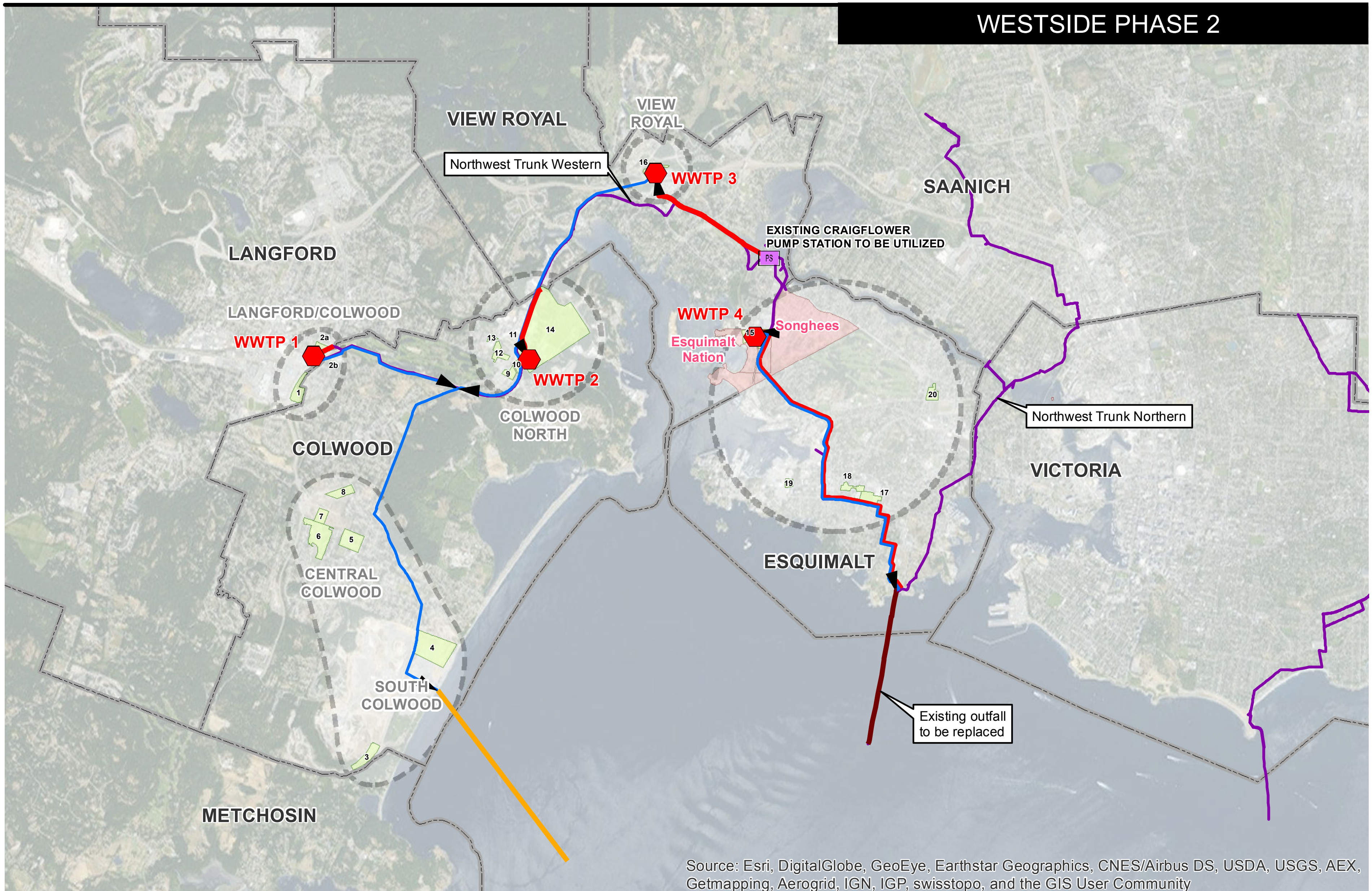
Esquimalt Village Site 17 was originally part of Option 4A and 2C and can be considered further however it is a relatively small site and will require flow synergies with plants located on the Eastside. Further feasibility analysis in Phase 2 can confirm the potential for Site 17. Additional costs related to maintaining its use as a park will increase site improvement costs. Also, Site 4 in South Colwood was not considered for 2030 design scenarios however it demonstrates some potential for phasing new sites over time to accommodate population growth and increased flows.

7.3 Option 4A (Revised) – Four Plants

7.3.1 Description

Figure 7.1 illustrates four treatment plants across the Westside with one facility in each community. Plant technologies and processes for small, medium and large plants meet the representative design considerations laid out earlier in the memo. In particular, the larger plant would be constructed to treat the full 4 x ADWF to a primary level as well as the balance of 2 x ADWF to a secondary level, recognizing that the largest portion of the effluent will be discharged to the ocean. Option 4A is revised in this analysis because the only site that has enough area is the Esquimalt First Nation, so it replaces the Esquimalt Village site (#17).

WESTSIDE PHASE 2



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Legend

- Municipal Boundary
- First Nation Reserve
- Site Nodes
- Existing Sanitary Trunkmain
- PS Existing Pump Station
- Raw Sewage Forcemain
- Treated Effluent Forcemain
- New Outfall
- Potential WWTP

Client/Project

CAPITAL REGIONAL DISTRICT
WESTSIDE PHASE 2

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WESTSIDE OPTION SETS
FOUR PLANT OPTION

Table 7.1 summarizes usable areas for each of the four sites, as well as a footprint requirement for 2030 and a conceptual estimate of area required for 2045.

Table 7.1 – Site Locations Area and Ownership

Community	WWTP Site	Estimated Usable Area	Estimated Required Area (ha)		Ownership
			2030	2045	
Langford	2a	1.89 ha	1.1	1.6	Private
Colwood	11	0.74 ha	0.6	1.1	Municipal
View Royal	16	1.13 ha	0.4	0.8	Provincial
Esquimalt First Nation	15	3.72 ha	2.4	3.7	First Nation

The estimated site area requirements in Table 7.1 illustrate that there is sufficient area at all four plant sites to accommodate the 2045 design flows.

7.3.2 Option Set Components

Plant 1 – Langford

1. Tie-in to CRD trunk main.
2. Sewage pump station adjacent to CRD trunk at east boundary of Langford (to pump 2 x ADWF from Langford). Note the 2 to 4 x ADWF is left in the trunk for treatment at EFN.
3. Short sewage forcemain to plant on Site 2a.
4. Plant on Site 2a with headworks (grit and screens), tertiary treatment with UV disinfection. Residual solids would be dewatered and trucked to the EFN treatment site.
5. Effluent pump station (part of the plant).
6. Effluent forcemain to connect to the other forcemains.

Plant 2 – Colwood North

1. Tie-in to CRD trunkmain at east boundary of Colwood.
2. Sewage pump station at east boundary of Colwood and CRD trunk (2 x ADWF from Colwood) to pump to new plant on Site 11. Note 2 to 4 x ADWF is left in the trunk to be treated at EFN.
3. Sewage forcemain to plant.
4. Plant on Site 11 with headworks (grit and screening), tertiary treatment with UV disinfection. Residual solids will be dewatered and trucked to EFN.
5. Effluent pump station (part of plant).

6. Effluent forcemain to connect to other forcemains and new outfall.
7. Outfall to handle Langford/Colwood/View Royal flows.

Plant 3 – View Royal

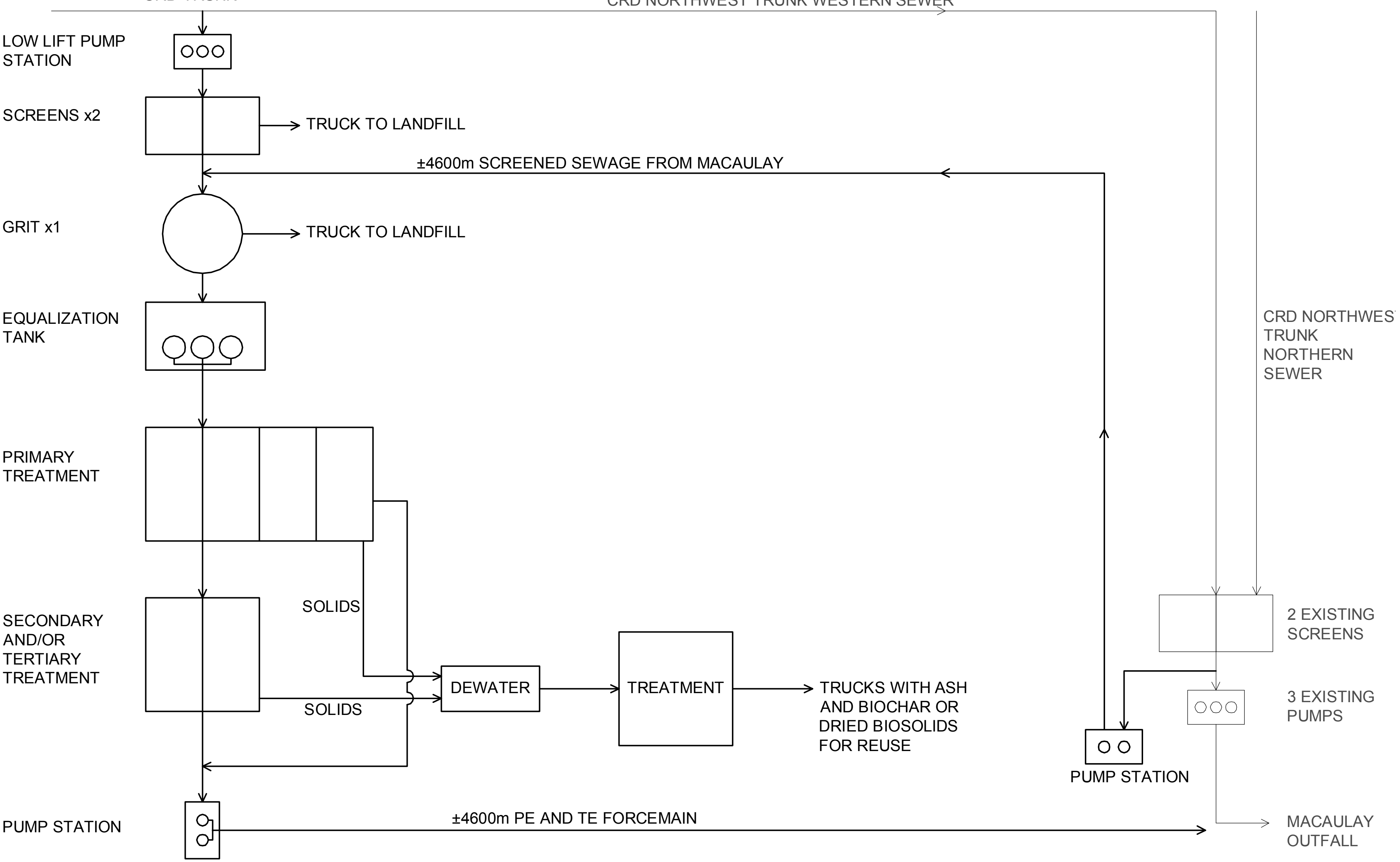
1. Reorient part of Craigflower Lift Station to pump 2 x ADWF (from most of View Royal) to the new plant on Site 16. The other portion of the Craigflower LS will continue to pump the 2 to 4 x ADWF from Langford/Colwood and View Royal on to EFN.
2. Sewage forcemain to plant.
3. Plant on Site 16 to provide headworks (grit and screens), and tertiary treatment with UV disinfection. Note residuals solids can be discharged back into the raw sewage pipe network for treatment at EFN.
4. Effluent pump station (part of plant).
5. Effluent forcemain to connect to other effluent forcemains.

Plant 4 – Esquimalt First Nation

Refer to Figure 7.2 for a process schematic of this plant and the various pump stations required.

1. Tie-in to CRD trunkmain.
2. Pump station beside trunkmain to lift into plant.
3. Short forcemain into new plant.
4. Tie-in to pipe just downstream of the Macaulay Point screens.
5. Pump station at Macaulay Point to pump all flows (0 to 4 x ADWF) to new plant at EFN.
6. Screened sewage forcemain to plant (tie-in after screens at new plant).
7. Primary and secondary plant to include headworks (grit, screens), equalization, primary clarifiers with chemical addition, moving bed bioreactors, clarifiers and ultraviolet light disinfection.
8. Residual solids treatment facility (anaerobic digestion).
9. Effluent pump station.
10. Primary and secondary effluent forcemain with tie-in downstream of Macaulay screens.
11. Outfall to replace existing corroded one.

WESTSIDE PHASE 2



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ESQUIMALT FIRST NATION PLANT		

7.3.3 Cost Estimates

7.3.3.1 Capital Cost

The capital cost estimates are comprised of four main components – pump stations, piping, treatment plants and outfalls. It is noted that the pump stations and WWTPs have costs to the 2030 design flows, but the pipes have been costed to the 2045 design flows. Table 7.2 summarizes the capital costs for the four plant option.

Table 7.2 Capital Cost Estimate for Four Plants

Item	Estimated Cost
1. Langford WWTP (28 MLD) Tertiary and Centrifuge	$ 50,600,000
2. Colwood WWTP (10 MLD) Tertiary and Centrifuge	$ 31,300,000
3. View Royal WWTP (7 MLD) Tertiary	$ 21,600,000
4. Esquimalt First Nation WWTP (145/50 MLD Primary/Secondary) plus Solids Treatment	$ 81,770,000
5. CRD Trunk Tie-Ins (4)	$ 3,300,000
6. Piping 23,350 m, not including reuse networks	$ 27,397,000
7. Esquimalt Effluent Reuse Network	$ 5,950,000
8. Colwood Effluent Reuse network	$ 7,000,000
9. Ten Pump Stations, Including Esquimalt Reuse Pump Station	$ 34,200,000
10. New Outfall 2,550 m @ 0.75 m Ø	$ 17,850,000
11. Replace Macaulay Outfall 1,700 m @ 1.2 m Ø	$ 16,320,000
Subtotal	**$ 297,287,000**
General Requirements (Bonding, Mobilization/Demobilization, etc.) - 10%	$ 29,728,700
Contractor Profit/Overhead - 10%	$ 29,728,700
Construction Contingency - 35%	$ 104,050,450
Total Direct Costs	**$ 460,794,850**
Engineering - 15%	$ 69,119,228
CRD Administration - 8%	$ 36,863,588
Interim Financing - 4%	$ 18,431,794
Escalation to Mid-Point of Construction – 2%/year (4 years)	$ 37,984,315
TOTAL PROJECT COSTS	**$ 623,194,000**

7.3.3.2 Operating Costs

The annual operating costs assuming 2030 design flows and 2015 dollars are summarized in Table 7.3.

Table 7.3 – Operating Cost Estimate for Four Plants

Item			Estimated Annual Cost
1.	Langford WWTP	(28 MLD) - Liquid	$ 2,877,000
		(28 MLD) – Solids - Centrifuge	$ 175,000
2.	Colwood WWTP	(10 MLD) - Liquid	$ 1,514,500
		(10 MLD) - Solids	$ 93,000
3.	View Royal WWTP	(7 MLD) - Liquid	$ 1,139,500
		(7 MLD) - Solids	$ 0
4.	Esquimalt First Nation WWTP	(145/50) - Liquid	$ 3,968,500
		(145/50) - Solids	$ 2,128,000
5.	Pump Stations and Piping and Effluent Reuse Systems (2)		$ 1,324,000
		Subtotal	**$ 13,219,500**
		Contingency (10%)	$ 1,321,950
		TOTAL ANNUAL ESTIMATED OPERATING COST	**$ 14,541,450**

7.3.3.3 Anticipated Revenue

- Revenues from solids-energy recovery can be utilized to offset the costs of treatment and solids processing and market development but are unlikely to present incomes beyond the expenditures of the system.
- Water revenues phase in over-time with the potential of approximately $3,000,0000 in 2045. This amount may cover the operating costs of one of the distributed plants (e.g. Colwood) that is if capital financing is not included. This means that based on projected demand for treated effluent reuse, that there will be much less revenue than there will be added cost for three MBR plants. Further life-cycle analysis and risk considerations, including any reductions to potable water revenues (other CRD service) are needed as part of Phase 2.
- Carbon offsets typically range in the order of $10 - $20 per tonne of CO2 equivalent. Carbon offsets for solids recovery will be analysed in Phase 2 for the Core Area.

7.3.3.4 Life Cycle Costs

Preliminary results strongly suggest that higher levels of treatment including MBR technologies provide for opportunities for reuse but notably increase capital as well as operating and maintenance costs. Water revenues alone are unlikely to recover these costs over time although there are may be opportunities to reduce the need for outfalls (the case of Colwood) which may create notable cost-offsets from reuse.

7.3.4 Relevant Considerations

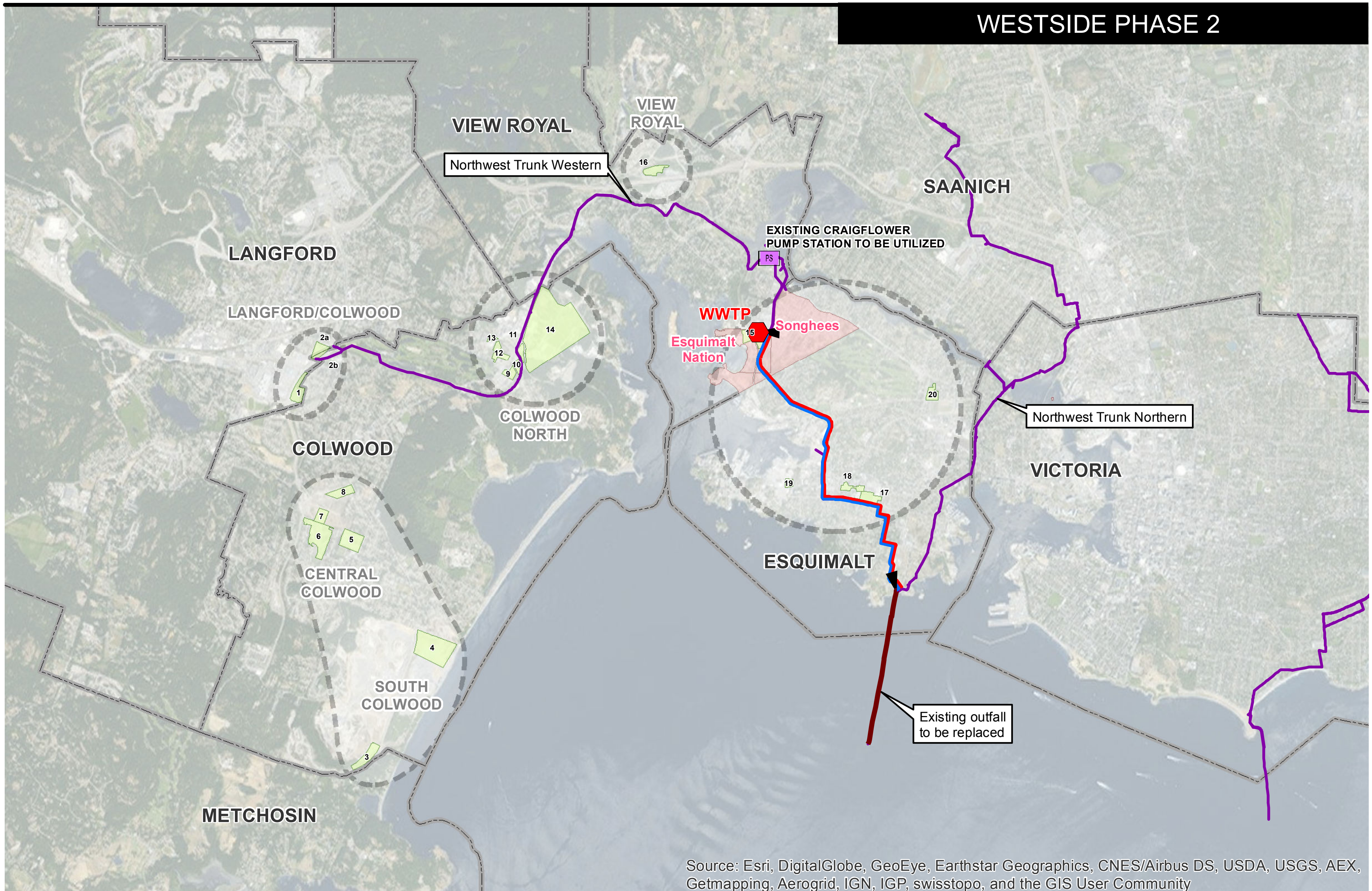
1. No new environmental impact study (EIS) is expected for the Macaulay outfall.
2. The flow from all Westside, West Saanich and Vic West are included in this option.
3. Aesthetically pleasing structures could enhance the neighbourhoods.
4. Reclaimed water could be extracted from the treated effluent line for reuse around each plant and between EFN and Macaulay Point and between Sites 16, 10, 2a and the new outfall.
5. Heat recovery is possible at the treatment plants and along all trunk lines.
6. Can intercept 0 to 4 x ADWF from trunk line beside EFN to avoid repumping it from Macaulay.
7. Colwood would have to relocate the Park n' Ride on Site 11.
8. A new EIS would be required for the new outfall.
9. There will likely be some constraints on Site 16 imposed by a BC Hydro easement for the high voltage power lines.
10. Maximum reuse opportunities with four plants, including effluent reuse networks in Colwood and Esquimalt.
11. Purchase of land from private landowners is required.
12. Agreements with EFN need to be made for use of their land.
13. This the highest life cycle cost of the three options.

7.4 Option 1B

7.4.1 Description

This 1-plant option is located on the Esquimalt First Nation as illustrated in Figure 7.3. Recent site area analysis requirements indicate that there is sufficient area for the 2030 liquid and solids treatment processes, but may be too small to accommodate flows well beyond 2030. Space constraints at the Esquimalt Nation site should be considered in future phases as 2045 flows become available. The primary intent of this option is to meet the federal and provincial regulations with discharge through the Macaulay outfall. The plant is located close to the CRD trunk sewer on Admirals Road. Consequently, it will be possible to capture and pump all of the upstream flows from Langford, Colwood and View Royal.

WESTSIDE PHASE 2



Legend

- Municipal Boundary
- First Nation Reserve
- Site Nodes
- Existing Sanitary Trunkmain
- Existing Pump Station
- Raw Sewage Forcemain
- Treated Effluent Forcemain
- New Outfall
- Potential WWTP

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WESTSIDE OPTION SETS ONE PLANT OPTION		

The balance of the flows from the two First Nations, Esquimalt, west Saanich and west Victoria will be pumped to the plant from the Macaulay Point outfall. After treatment all of the flow will be pumped back to the Macaulay outfall.

The plant will be able to treat the full 4 x ADWF to a primary level, as well as the first 2 x ADWF to a secondary level.

7.4.2 Option Set Components

Figure 7.2 also illustrates the various components required for this option. The following components are noted:

1. Tie-in to CRD trunkmain.
2. Pump station beside trunkmain to lift into plant.
3. Short forcemain into new plant.
4. Tie-in to pipe just downstream of Macaulay screens.
5. Short pipe into pump station.
6. Pump station at Macaulay Point to pump all flows (0 to 4 x ADWF) to new WWTP at Esquimalt First Nation.
7. Screened sewage forcemain to new WWTP (tie-in after screens at new plant).
8. Primary and Secondary plant to include headworks (grit, screens), equalization, primary clarifiers with chemical addition, moving bed bioreactors, clarifiers, and ultraviolet light disinfection.
9. Residual solids treatment including anaerobic digestion and dewatering.
10. Effluent pump station (part of plant).
11. Primary and secondary effluent forcemain back to Macaulay Point outfall, tie-in downstream of the screens.
12. Outfall to replace existing corroded one.

7.4.3 Cost Estimates

7.4.3.1 Capital Cost

The capital cost estimates are comprised of four main components – pump stations, piping, treatment plants and outfalls. It is noted that the pump stations and WWTPs have costs to the 2030 design flows, but the pipes have been costed to the 2045 design flows. Table 7.4 summarizes the capital costs for the one plant option.

Table 7.4 Capital Cost Estimate for One Plant

Item	Estimated Cost
1. Esquimalt First Nation WWTP (190/95 MLD Primary/Secondary) Plus Solids Treatment	$ 139,000,000
2. CRD Trunk Tie-Ins (two)	$ 2,400,000
3. Piping 9,500 m, Not Including Effluent Reuse	$ 20,335,000
4. Esquimalt Effluent Reuse Network	$ 5,950,000
5. Four Pump Stations, Including Esquimalt Reuse Pump Station	$ 28,800,000
6. Replace Macaulay Outfall – 1,700 m @ 1.2 m Ø	$ 18,360,000
Subtotal	**$ 214,845,000**
General Requirements (Bonding, Mobilization/Demobilization, etc.) - 10%	$ 21,484,500
Contractor Profit/Overhead - 10%	$ 21,484,500
Construction Contingency - 35%	$ 75,195,750
Total Direct Costs	**$ 333,009,750**
Engineering - 15%	$ 49,951,763
CRD Administration - 8%	$ 26,640,740
Interim Financing - 4%	$ 13,320,870
Escalation to Mid-Point of Construction – 2%/year (4 years)	$ 27,450,824
TOTAL PROJECT COSTS	**$ 450,374,000**

7.4.3.2 Operating Costs

The annual operating costs assuming 2030 design flows and 2015 dollars, are summarized in Table 7.5.

Table 7.5 – Operating Cost Estimate for One Plant

Item		Estimated Annual Cost
1. Esquimalt First Nation WWTP	Liquid	$ 7,167,000
	Solids	$ 3,689,000
2. Pump Stations and Piping and Effluent Reuse System		$ 856,000
Subtotal		**$ 11,712,000**
Contingency (10%)		$ 1,171,200
TOTAL ANNUAL ESTIMATED OPERATING COST		**$ 12,883,200**

7.4.3.3 Anticipated Revenue

The anticipated revenues are listed below.

- Revenues from solids-energy recovery can be utilized to offset the costs of treatment and solids processing and market development but are unlikely to present incomes beyond the expenditures of the system.
- Water revenues phase in over-time with the potential of approximately $1,000,0000 in 2045. This amount is unlikely to cover the operating costs of a small MBR (‘slipstream’ type installation) even when capital financing is not included. Further life-cycle analysis and risk considerations, including any reductions to potable water revenues (other CRD service) are needed as part of Phase 2.
- Carbon offsets typically range in the order of $10 - $20 per tonne of CO2 equivalent. Carbon offsets for solids recovery will be analysed in Phase 2 for the Core Area.

7.4.3.4 Life Cycle Costs

Preliminary costing analysis suggests that the 1-plant option provides for the lowest capital and operating option for the Westside. Further cost savings may be realized by looking for further efficiencies and synergies through Core Area analysis.

7.4.4 Relevant Considerations

1. The usable area of the EFN site (3.72 ha) is inadequate to handle the full 2045 flows.
2. No new environmental impact study (EIS) is expected for the Macaulay outfall.
3. The flow from all Westside, West Saanich and Vic West are included in this option.
4. Aesthetically pleasing structures could enhance the neighbourhoods.
5. Heat recovery is possible at the treatment plants and along all trunk lines.
6. Can intercept 0 to 4 x ADWF from trunk line beside EFN to avoid repumping it from Macaulay.
7. Reclaimed water could be extracted from the 4,600 m long effluent forcemain for reuse between the plant and Macaulay outfall.
8. Agreements need to be made with the Esquimalt First Nation for their land.
9. This option incorporates an effluent reuse network in Esquimalt.
10. This is the option with the lowest life cycle cost.

7.5 Option 2C Revised – Two Plants

7.5.1 Description

Option 2C is illustrated in Figure 7.4 and includes two important improvements from the original version (June 2015). First is that the plant in Colwood North does not discharge to its own outfall. Instead all of the effluent is reused for irrigation and aquifer recharge – which is estimated to have a maximum capacity of 10 MLD to 30 MLD. If the plant were not able to meet the effluent criteria, for whatever reason, it would be discharged into the CRD trunkmain for treatment at the large plant at Esquimalt Nation.

The second revision to Option 2C is that the extra-large plant is located at the Esquimalt First Nation, not on the Esquimalt Village site (#17). This is because site 17 does not appear able to accommodate the large facility as it increases in size and capacity to meet growth. Phase 2 analysis as part of the Core Area should consider synergies between sites on both Eastside and Westside for longer-term upsizing potential.

7.5.2 Components

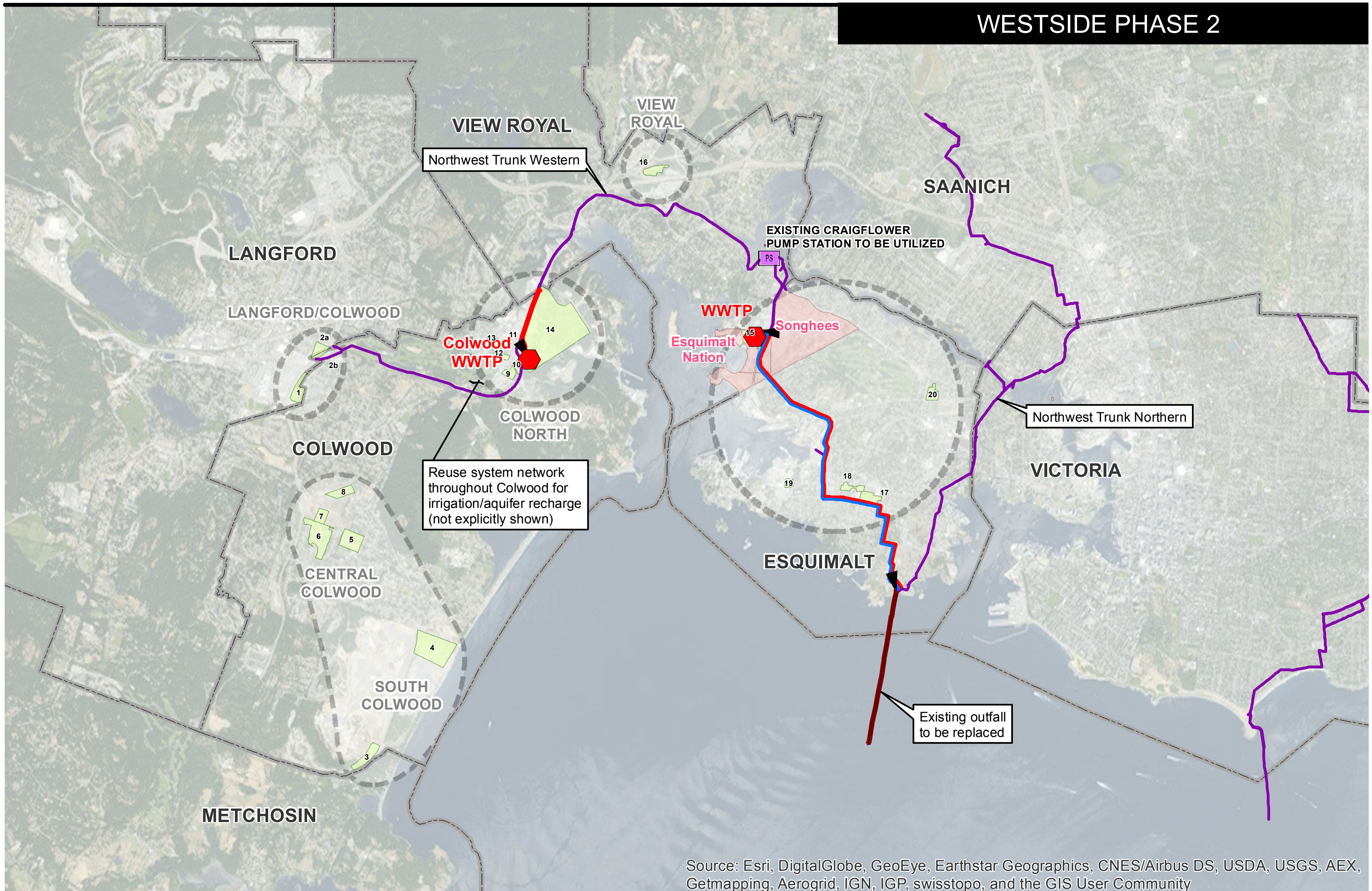
Colwood Plant (10 MLD)

1. CRD tie-in to trunk at east boundary of Colwood.
2. Sewage pump station at east boundary of Colwood and CRD trunk (2 x ADWF from Colwood) to pump to new plant on Site 11. Note that 2 to 4 ADWF remains in trunk to be treated by plant at EFN.
3. Sewage forcemain to plant.
4. Plant on Site 11 with headworks (grit, screens), tertiary treatment with UV disinfection. Residual solids will be directed back into the CRD trunk for treatment at the new plant at EFN.
5. Effluent pump station (part of plant).
6. Network of pipes, valves, controls to distribute around Colwood for irrigation/aquifer recharge.
7. Failsafe valving and piping for effluent back to the CRD trunk in the event effluent quality does not meet the criteria for reuse.

Esquimalt First Nation Plant

1. Tie-in to CRD trunkmain.
2. Pump station beside trunkmain to lift into plant.
3. Short forcemain into new plant.
4. Tie-in to pipe just downstream of Macaulay screens.

WESTSIDE PHASE 2



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Legend

- Municipal Boundary
- First Nation Reserve
- Site Nodes
- Existing Sanitary Trunkmain
- PS Existing Pump Station
- Raw Sewage Forcemain
- Treated Effluent Forcemain
- New Outfall
- Potential WWTP

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WESTSIDE OPTION SETS TWO PLANT OPTION		

5. Short pipe into pump station.
6. Pump station at Macaulay Point to pump all flows (0 to 4 x ADWF) to new WWTP at Esquimalt First Nation.
7. Screened sewage forcemain to new WWTP (tie-in after screens at new plant).
8. Primary and Secondary plant to include headworks (grit, screens), equalization, primary clarifiers with chemical addition, moving bed bioreactors, clarifiers, and ultraviolet light disinfection.
9. Residual solids treatment including dewatering anaerobic digestion and dewatering.
10. Effluent pump station (part of plant).
11. Primary and secondary effluent forcemain back to Macaulay Point outfall, tie-in downstream of the screens.
12. Outfall to replace existing corroded one.

7.5.3 Cost Estimates

7.5.3.1 Capital Cost

The capital cost estimates are comprised of four main components – pump stations, piping, treatment plants and outfalls. It is noted that the pump stations and WWTPs have costs to the 2030 design flows, but the pipes have been costed to the 2045 design flows. Table 7.6 summarizes the capital costs for the two plant option.

Table 7.6 Capital Cost Estimate for Two Plants

Item	Estimated Cost
1. Esquimalt First Nation WWTP (190/95 MLD Primary/Secondary) Plus Solids Treatment	$ 139,000,000
2. Colwood WWTP (10 MLD) – No Solids Dewatering	$ 29,800,000
3. CRD Trunk Tie-Ins (3)	$ 2,850,000
4. Piping 10,650 m, Not Including Reuse Piping in Colwood & Esquimalt	$ 21,071,000
5. Colwood Reuse Network	$ 7,000,000
6. Esquimalt Reuse Network	$ 5,950,000
7. Six Pump Stations, Including Esquimalt Reuse Pump Station	$ 31,700,000
8. Replace Macaulay Outfall – 1700 m @ 1.2 m Ø	$ 18,360,000
Subtotal	**$ 255,731,000**
General Requirements (Bonding, Mobilization/Demobilization, etc.) - 10%	$ 25,573,100
Contractor Profit/Overhead - 10%	$ 25,573,100
Construction Contingency - 35%	$ 89,505,850
Total Direct Costs	**$ 396,383,050**

Item	Estimated Cost
Engineering - 15%	$ 59,457,458
CRD Administration - 8%	$ 31,710,644
Interim Financing - 4%	$ 15,855,322
Escalation to Mid-Point of Construction – 2%/year (4 years)	$ 32,674,711
TOTAL PROJECT COSTS	**$ 536,081,000**

7.5.3.2 Operating Costs

The annual operating costs assuming 2030 design flows and 2015 dollars, are summarized in Table 7.7.
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Table 7.7 – Operating Cost Estimate for Two Plants

Item		Estimated Annual Cost
1. Esquimalt First Nation WWTP	Liquid	$ 7,167,000
	Solids	$ 3,689,000
2. Colwood WWTP	Liquid Only	$ 1,514,500
3. Pump Stations and Piping and Effluent Reuse Systems (2)		$ 1,052,100
Subtotal		**$ 13,422,600**
Contingency (10%)		$ 1,342,260
TOTAL ANNUAL ESTIMATED OPERATING COST		**$ 14,764,860**

7.5.3.3 Anticipated Revenue

The anticipated revenues are listed below.

- Revenues from solids-energy recovery can be utilized to offset the costs of treatment and solids processing and market development but are unlikely to present incomes beyond the expenditures of the system.
- Water revenues phase in over-time with the potential of approximately $3,000,0000 in 2045. This amount may cover the operating costs of the Colwood plant when capital financing is not included. Further life-cycle analysis and risk considerations, including any reductions to potable water revenues (other CRD service) are needed as part of Phase 2. If 'slipstream' MBR is added to the main plant at Esquimalt, it will likely add additional capital and operating costs that will not be recovered through water reuse revenues.

- Carbon offsets typically range in the order of \$10 - \$20 per tonne of CO_2 equivalent. Carbon offsets for solids recovery will be analysed in Phase 2 for the Core Area.

7.5.3.4 Life Cycle Costs

Preliminary results strongly suggest that higher levels of treatment including MBR technologies provide for opportunities for reuse but notably increase capital as well as operating and maintenance costs. Water revenues alone are unlikely to recover these costs over time although there are may be opportunities to reduce the need for outfalls (the case of Colwood) which may create notable cost-offsets from reuse. The two-plant option provides for greater water reuse, is appreciably less cost than the four-plant option yet is notably greater cost than the 1-plant option.

7.5.4 Relevant Considerations

1. The area of the EFN site (3.72 ha) is inadequate to handle the full 2045 flows.
2. No new environmental impact study (EIS) is expected for the Macaulay outfall.
3. The flow from all Westside, West Saanich and Vic West are included in this option.
4. Aesthetically pleasing structures could enhance the neighbourhoods.
5. Heat recovery is possible at the treatment plants and along all trunk lines.
6. Colwood would have to relocate the Park n' Ride on Site 11.
7. Reclaimed water could be extracted from the 4,600 m long effluent forcemain for reuse between the plant and Macaulay outfall.
8. Agreements with EFN need to be made for use of their land.
9. Can intercept 0 to 4 x ADWF from trunk line beside EFN to avoid repumping it from Macaulay.
10. This option maximizes the known (or at least well studied) reuse opportunities of irrigation/aquifer recharge in the Colwood area.
11. This option includes an effluent reuse network in Esquimalt as well.
12. The alternative method of disposal for the Colwood plant is discharge back into the CRD trunk for treatment of the extra-large EFN plant.
13. Residual solids do not need to be dewatered and trucked away from the Colwood plant, since the waste solids can be put into the CRD sewer for treatment at EFN.
14. This option has higher life cycle costs than the one plant option.

Appendix A

Derivation of 2045 Flows

2045 ADWF Calculation

Area	2015 - 2045 Residential Growth Rates (%) [1]	2045 Residential & ICI Total Population Equivalents [1]	2045 Residential & ICI Flows (MLD) [2]	2045 Base Groundwater Infiltration (MLD) [5]	2045 ADWF (MLD)	
Saanich	0.5	184,424	36.0	9.7	45.7	West = 32.9 / East = 12.8
Victoria	0.5	151,589	[3]	[3]	40.8 [3]	West = 6.8 / East = 34.0
Esquimalt	0.5	30,140	[4]	[4]	7.9 [4]	
Langford	2.9	93,189	18.2	4.9	23.1	
Colwood	1.5	52,697	10.3	2.8	13.1	
View Royal	1.5	31,867	6.2	1.7	7.9	
Oak Bay	0.1	26,670	5.2	1.4	6.6	
Subtotal		**570,576**			**145.1**	
Esquimalt First Nation	-	-	-	-	0.4 [6]	
Songhees First Nation	-	-	-	-	0.5 [6]	
				Total	**146**	

[1] 033-DP-1

[2] Assume 195 Lcd, from CALWMP Amendment #8

[3] Equilavent Population increase estimate from 2030 is 10,000 people - increase 2030 flow by 10,000 x 195 Lcd x 1.27 = 2.5 MLD or 38.3 + 2.5 = 40.8

[4] Population increase estiamte from 2030 is 3274 - increae 2030 flow by 3274 x 195 Lcd x 1.27 = 0.8 MLD or 7.1 + 0.8 = 7.9

[5] LWMP Amendment 8 - 2030 ADWF = 108 MLD for Core Area

Equivalent Population in 2030 is 436,032 x $195 \frac{L}{\text{person}\bullet\text{day}} = 85$ MLD

Base GWI = 108 - 85 = 23

BGWI is $\frac{23}{85}$ = 27% of the Residential + ICI Flows

[6] Increase 2030 EFN and SFN flows by 145.1/108 = 1.33

Appendix B

2014 Influent Quality Data

Macaulay **Screened Raw Sewage 2014**

Parameter	State	Unit	requency of Detectio	Average Concentration	n	Max Concentration	Min concentration	1:175 Dilution	BC WQG	CCME WQG
alkalinity - total - pH 4.5	TOT	mg/L	75%	217.7	9	273.0	188.0	1.1		
biochemical oxygen demand	TOT	mg/L	100%	275.8	12	376.7	180.0	1.5		
chemical oxygen demand	TOT	mg/L	100%	632.5	12	816.0	433.3	3.3		
carbonaceous biochemical ox	TOT	mg/L	100%	226.4	12	291.0	162.0	1.2		
cyanide-SAD	TOT	mg/L	100%	0.00256	9	0.00334	0.00173	0.00001		
cyanide-WAD	TOT	mg/L	100%	0.00148	10	0.00263	0.00083	0.00001	0.001b	
hardness (as CaCO3)	DISS	mg/L	100%	76.8	12	112.7	55.1	0.5		
hardness (as CaCO3)	TOT	mg/L	100%	88.6	12	127.7	63.6	0.5		
oil & grease, total	TOT	mg/L	100%	8.8	10	17.3	4.9	0.1		
oil & grease, mineral	TOT	mg/L	25%	ND	3	3.30	2.00	0.01		
pH	TOT	pH	100%	7.34	12	7.71	7.10	0.03		
pH @ 15° C	TOT	pH	100%	6.99	12	7.19	6.77	0.03		
specific conductivity - 25°C.	TOT	µS/cm	100%	794.4	12	971.0	649.3	4.0		
sulphate	TOT	mg/L	100%	29.3	2	39.6	18.9	0.2		
sulfide	TOT	mg/L	100%	0.353	11	0.632	0.125	0.003	0.002cf	
temperature	TOT	°C	100%	17.2	12	20.5	13.3	0.1		
enterococci	TOT	CFU/100 mL	100%	2,584,848	12	4,266,667	1,633,333	17,000	20j	35/70n
fecal coliforms	TOT	CFU/100 mL	100%	8,563,636	12	29,000,000	4,200,000	118,000	200j	
N - TKN (as N)	TOT	mg/L	100%	54.4	12	70.3	40.5	0.3		
N - NH3 (as N)	TOT	mg/L	100%	42.4	8	49.0	35.3	0.2		
N - NH3 (as N)- unionized	TOT	mg/L	100%	0.115	12	0.190	0.058	0.001	19.7e	
N - NO2 (as N)	TOT	mg/L	75%	0.041	9	0.253	0.005	0.001		
N - NO3 (as N)	TOT	mg/L	25%	ND	3	0.020	0.005	---		
N - NO3 + NO2 (as N)	TOT	mg/L	0%	ND	0	0.0200	0.0200	---		
P - PO4 - total (as P)	DISS	mg/L	100%	4.3	10	5.75	2.63	0.02		
P - PO4 - total (as P)	TOT	mg/L	100%	5.5	12	6.81	3.89	0.03		
P - PO4 - ortho (as P)	TOT	mg/L	100%	3.8	12	4.96	2.02	0.02		
total organic carbon	TOT	mg/L	100%	82	11	144.0	42.6	0.6		
total suspended solids	TOT	mg/L	100%	270	12	332	168	1.4		
aluminum	TOT	mg/L	100%	0.3	12	0.365	0.203	0.001		
antimony	TOT	mg/L	100%	0.0003	12	0.000399	0.000243	0.000002		
arsenic	TOT	mg/L	100%	0.0006	12	0.00084	0.00044	0.000003	0.0125cg	0.0125
barium	TOT	mg/L	100%	0.02	12	0.0387	0.0137	0.0002	0.5ac	
beryllium	TOT	mg/L	0%	ND	0	0.0000100	0.0000100	---		
cadmium	TOT	mg/L	100%	0.0002	12	0.000275	0.000139	0.000001	0.00012c	0.000120
calcium	TOT	mg/L	100%	21.7	12	29.3	16.8	0.1		
chloride	TOT	mg/L	100%	89.1	8	140.3	75.0	0.6		
chromium	TOT	mg/L	100%	0.002	12	0.00298	0.00116	0.00001		
chromium VI	TOT	mg/L	25%	ND	3	0.00120	0.00100	---		
cobalt	TOT	mg/L	100%	0.0009	12	0.001310	0.000504	0.000005	0.000004	
copper	TOT	mg/L	100%	0.12	12	0.169	0.081	0.001	0.001	0.003bh

Clover **Screened Raw Sewage 2014**

Parameter	State	Unit	Frequency of Detection	Average Concentration	n	Max Concentration	Min concentration	1:175 Dilution	BC WQG	CCME WQG
alkalinity - total - pH 4.5	TOT	mg/L	75%	168	9	179.3	154.3	1.0		
biochemical oxygen demand	TOT	mg/L	100%	238	12	305.0	184.0	1.7		
chemical oxygen demand	TOT	mg/L	100%	530	12	686.0	301.3	3.9		
carbonaceous biochemical oxygen	TOT	mg/L	100%	192	12	248.3	118.3	1.4		
cyanide-SAD	TOT	mg/L	100%	0.002	9	0.00257	0.00158	0.00001		
cyanide-WAD	TOT	mg/L	100%	0.0013	10	0.00216	0.00071	0.00001	0.001b	
hardness (as CaCO3)	DISS	mg/L	100%	63.9	12	90.4	49.0	0.5		
hardness (as CaCO3)	TOT	mg/L	100%	73.2	12	97.9	60.1	0.6		
oil & grease, total	TOT	mg/L	100%	9.7	10	24.3	3.5	0.1		
oil & grease, mineral	TOT	mg/L	42%	ND	5	4.00	2.00	0.02		
pH	TOT	pH	100%	7.33	12	7.71	7.10	0.04		
pH @ 15° C	TOT	pH	100%	6.89	12	7.15	6.24	0.04		
specific conductivity - 25°C.	TOT	µS/cm	100%	528.1	12	568.0	481.0	3.2		
sulphate	TOT	mg/L	100%	20.6	2	24.1	17.0	0.1		
sulfide	TOT	mg/L	100%	0.246	11	0.424	0.092	0.002	0.002cf	
temperature	TOT	°C	100%	18.4	12	21.2	14.9	0.1		
enterococci	TOT	CFU/100 mL	100%	2,255,556	12	4,500,000	766,667	25,714	20j	35/70n
fecal coliforms	TOT	CFU/100 mL	100%	6,433,333	12	14,333,333	3,033,333	81,886	200j	
N - TKN (as N)	TOT	mg/L	100%	40.8	12	51.7	28.9	0.3		
N - NH3 (as N)	TOT	mg/L	100%	27.1	8	34.0	13.3	0.2		
N - NH3 (as N)- unionized	TOT	mg/L	100%	0.058	12	0.120	0.012	0.001	19.7e	
N - NO2 (as N)	TOT	mg/L	92%	0.063	11	0.187	0.005	0.001		
N - NO3 (as N)	TOT	mg/L	50%	ND	6	0.489	0.006	0.003		
N - NO3 + NO2 (as N)	TOT	mg/L	0%	ND	0	0.0200	0.0200	0.0001		
N - Total (as N)	TOT	mg/L	100%	40.3	1	40.3	40.3	0.2		
P - PO4 - total (as P)	DISS	mg/L	100%	3.40	10	4.30	1.88	0.02		
P - PO4 - total (as P)	TOT	mg/L	100%	4.36	12	5.74	2.76	0.03		
P - PO4 - ortho (as P)	TOT	mg/L	100%	2.91	12	4.04	1.75	0.02		
total organic carbon	TOT	mg/L	100%	61.9	11	118.0	30.8	0.7		
total suspended solids	TOT	mg/L	100%	238.4	12	292.0	166.0	1.7		
aluminum	TOT	mg/L	100%	0.310	12	0.435	0.217	0.002		
antimony	TOT	mg/L	100%	0.000258	12	0.000380	0.000186	0.000002		
arsenic	TOT	mg/L	100%	0.00066	12	0.00111	0.00050	0.00001	0.0125cg	0.0125
barium	TOT	mg/L	100%	0.0214	12	0.0253	0.0120	0.0001	0.5ac	
beryllium	TOT	mg/L	8%	ND	1	0.0000103	0.0000100	0.0000001		
cadmium	TOT	mg/L	100%	0.000157	12	0.000260	0.000100	0.000001	0.00012c	0.00012
calcium	TOT	mg/L	100%	18.8	12	25.4	16.3	0.1		
chloride	TOT	mg/L	100%	42.8	8	45.7	39.0	0.3		
chromium	TOT	mg/L	100%	0.00100	12	0.00155	0.00069	0.00001		
chromium VI	TOT	mg/L	0%	ND	0	0.00133	0.00100	0.00001		
cobalt	TOT	mg/L	100%	0.000360	12	0.000506	0.000289	0.000003	0.000004	

Appendix C

Ammonia Toxicity Memorandum

MEMORANDUM

Date:	September 23, 2015
To:	Chris Town, P.Eng.
cc:	Ehren Lee, P.Eng., Steve Brubacher, P.Eng.
From:	Dr. Joanne Harkness, R.P.Bio.
File:	1692.0037.01
Subject:	Requirements for Ammonia Treatment

1. INTRODUCTION

The CRD is currently assessing options for the management of the sanitary sewage which is produced by the area. The purpose of this memorandum is to provide a summary of the assessment which was completed to determine if treatment for ammonia will be required in order to meet Federal and Provincial regulatory requirements.

2. BACKGROUND TO AMMONIA IN MUNICIPAL WASTEWATER

Ammonia is the predominant form of nitrogen in untreated municipal wastewater and in municipal wastewater effluents where there is no nitrification (biological reduction of ammonia). Ammonia is one of the key parameters of concern with respect to sewage effluents and aquatic toxicity. Both acute and chronic toxicity need to be considered.

Acute toxicity refers to a rapid and extreme response to environmental conditions – i.e. death normally occurs within a short period of time. The standard test for determining acute toxicity in an aquatic environment is the LC50 96 hour rainbow trout bioassay. In this test, 10 young rainbow trout are used per test. If 6 fish die within 96 hours, the test solution is determined to be acutely toxic and has failed the toxicity test. Acute toxicity is the focus for effluent prior to release to the environment.

Chronic toxicity is less easy to define than acute toxicity as this type of toxicity refers to effects which may be observed over a long time period and which may be subtle in nature. Chronic toxicity could equate to impacts on off-spring of exposed individuals, metabolic differences or subtle changes in the ability to survive or reproduce. Due to the complexity of chronic toxicity, acute toxicity has historically been the primary focus for legislation and the regulatory government agencies. Chronic toxicity is the focus for environmental conditions, once the effluent has been released.

Ammonia is present in two forms: ionised and un-ionised, the proportion of which is dependent on pH and temperature. It is the un-ionised form of ammonia which is of particular interest, as this is the form which is toxic to fish. The un-ionised form of ammonia becomes the predominant form of ammonia as the pH increases. As a result, under alkaline conditions, it is possible for very low concentrations of ammonia to cause aquatic toxicity. Total ammonia is the sum of the ionised and un-ionised forms of ammonia.

3. REGULATORY BACKGROUND

3.1 Provincial Legislation and Guidelines

The Municipal Wastewater Regulation (MWR) is the regulatory framework for management of sewage in British Columbia. The MWR was published in April 2012, and replaced the Municipal Sewage Regulation, which was promulgated in 1999. The MWR outlines the effluent quality standards and discharge requirements for municipal wastewater treatment plants in British Columbia. For discharge to surface waters, the MWR indicates the expectations for effluent quality, dilution and defines the concept of an initial dilution zone (IDZ). The IDZ is an area immediately around the point of discharge where it is acceptable for degradation in water quality to occur. With respect to ammonia, the MWR focuses on meeting chronic ammonia concentrations at the edge of the IDZ. The concentration of ammonia in the effluent is to be back calculated based on the need to meet site-specific chronic conditions at the edge of the IDZ.

The Capital Regional District (CRD) has an approved Liquid Waste Management Plan (LWMP). A LWMP is a powerful document which is based on the current legislation. The completion of a LWMP results in a document which takes precedence over any existing permit or the MWR. Although a LWMP can provide an avenue for flexibility, the general intent of a LWMP is to develop a plan which will be implemented over time in order to meet the intent and conditions of the MWR.

The BC Water Quality Guidelines provide guidance as to suitable water quality for a range of different uses including drinking water, aquatic life, recreation and agriculture. The guidelines do not have any direct legal standing but are intended to be used as a tool to provide policy direction for decisions relating to water quality. These guidelines can be used to evaluate appropriate effluent criteria for release from a municipal wastewater treatment plant. For ammonia, there are acute and chronic guidelines for the protection of aquatic life for both marine and freshwater surface waters. The guideline value varies, depending on the temperature and pH. For marine waters, the salinity also needs to be taken into consideration. The BC Water Quality Guidelines define chronic as a 30 day average, based on 5 weekly samples taken over a 30 day period. This definition allows for an increased likelihood that a particular condition may both exist and persist in an environment.

3.2 Federal Legislation and Guidelines

The Federal wastewater regulation (the Wastewater Systems Effluent Regulations) was published in July, 2012 and applies to any surface water discharge in Canada where the average annual incoming flow to the sewage treatment plant is ≥ 100 m^3/d, with the focus being to protect surface waters which are regarded as fisheries resources. The regulation contains National Performance Standards, with the standard for ammonia being a maximum concentration of un-ionised ammonia of 1.25 mg/L, prior to release. The Federal regulation also recognises ammonia conditions after dilution in the receiving environment. In the event that the un-ionised ammonia concentration of 1.25 mg/L cannot be met before effluent release, then there is no need to upgrade for ammonia treatment as long as an un-ionised ammonia concentration of 0.016 mg/L is met in the receiving environment, 100 m away from the point of release. The discharger would need to apply for a temporary authorisation which is valid for 3 years. Re-application for the temporary authorisation would be required every 3 years, if the effluent is still acutely toxic.

3.3 Summary of Legislation

There are three regulatory criteria for ammonia, all of which have direct relevance to each other.

1. The Federal wastewater regulation stipulates a maximum un-ionised ammonia concentration of 1.25 mg/L, before release. This focuses on acute toxicity to fish.
2. The Federal wastewater regulation stipulates that in the event that the effluent un-ionised ammonia concentration is above 1.25 mg/L, treatment for ammonia is not required as long as the concentration of un-ionised ammonia in the receiving environment is ≤ 0.016 mg/L, at a distance 100 m from the point of effluent release. This focuses on chronic toxicity to fish.
3. The MWR stipulates that the concentration of ammonia at the edge of the IDZ is to meet fisheries chronic concentrations, based on conditions in the receiving environment for temperature and pH. There is no requirement in the MWR for acute ammonia toxicity.

4. EFFLUENT AMMONIA EVALUATIONS

4.1 MWR Evaluations

In order to estimate the chronic total ammonia concentration at the edge of the IDZ, historical data for temperature, pH and salinity were taken from the CRD monitoring program database for locations at the edge of the IDZ. The data indicated little variability in the pH (range pH 7.50 to 7.96). The 90th percentile of the whole dataset (pH 7.83) was used for the evaluation. There was also consistency in the temperature throughout the year, ranging from a low of 7.07 ^{o}C in January to a high of 12.44 ^{o}C in July. The 90th percentile of the July dataset (11.10 ^{o}C) was used for the evaluation. The data indicated that the salinity was in the order of 30 g/kg, which is the highest threshold indicated in the BC Water Quality Guidelines. Based on these data the total ammonia concentration at the edge of the IDZ should be less than or equal to 3.4 mg/L.

The evaluations focused on 90th percentile data rather than the maximum data. Maximum data represent the worst case scenario and the intent was to evaluate the potential for a chronic effect to occur, which requires conditions which have a likelihood of occurring on a regular basis for an extended period of time. Maximum data represent extreme events which occur for short periods of time. This is not the intent of the definitions in the BC Water Quality Guidelines, where chronic conditions are evaluated using 5 data points taken on a weekly basis over 5 consecutive weeks.

Table 4.1 summarises the chronic total ammonia concentration at the edge of the IDZ and the corresponding effluent total ammonia concentration for both the Macauley Point and Clover Point outfalls. The dilution ratio was taken from CRD customized oceanographic/plume modelling of the effluent dilution and dispersion at both outfall locations. The estimations do not take into account the background total ammonia concentration. However, this is a low concern given that the background total ammonia concentration is expected to be close to the analytical detection limit (e.g. in the order of 0.005 mg/L) and the estimated effluent concentrations which would be required to cause chronic ammonia conditions at the edge of the IDZ are significantly higher than what would be expected for untreated municipal wastewater. From this evaluation, since untreated municipal wastewater would have a maximum total ammonia concentration of 45 mg/L, there are no requirements to treat for ammonia to meet chronic ammonia conditions at the edge of the IDZ.

Table 4.1: Summary of End of IDZ Chronic Ammonia Concentration and the Corresponding Effluent Total Ammonia Concentration

Outfall Location	Edge of IDZ Chronic Total Ammonia Concentration to Meet MWR (mg/L)	Edge of IDZ Dilution Ratio	Corresponding Effluent Total Ammonia Concentration (mg/L)
Macaulay Point	≤ 3.4	245:1	≤ 833
Clover Point	≤ 3.4	175:1	≤ 595

4.2 Federal Wastewater Regulation Evaluations

The Federal wastewater regulation recognises both acute toxicity before effluent release and chronic toxicity at a point 100 m away from the point of release. For the effluent prior to release, the standard is a maximum un-ionised ammonia concentration of 1.25 mg/L. Table 4.2 summarises the pH range expected for a typical municipal wastewater effluent and the corresponding total ammonia concentration which would equate to an un-ionised ammonia concentration of 1.25 mg/L. The standard total ammonia concentration for untreated municipal wastewater is 25 mg/L. However, it is reasonable to expect that there will be periodic increases in the wastewater total ammonia concentration, with the concentration potentially being in the order of 45 mg/L. For a wastewater treatment plant that is not designed to nitrify, it is reasonable to expect that the effluent total ammonia concentration will typically be in the 25 mg/L range, but could periodically be as high as 45 mg/L. From this, although there would be no concerns with the acute un-ionised ammonia threshold of 1.25 mg/L being exceeded if the effluent pH is 7.5 or less, this may not be the case if the pH is in the order of 8.0, as the maximum effluent total ammonia concentration is very close to the acutely toxic threshold under these conditions.

Table 4.2: Effluent Total Ammonia Concentration to be Non-acutely Toxic

Effluent pH	Total Ammonia Concentration (mg/L)
7.0	≤ 455
7.5	≤ 148
8.0	≤ 47

In the event that the effluent is acutely toxic before release, there will be the need to consider the ability to meet chronically toxic concentrations after the release. Table 4.3 summarises the effluent un-ionised and total ammonia concentration required in order to meet an un-ionised ammonia concentration of 0.016 mg/L at the edge of the IDZ, which is approximately 100 m away from the point of effluent release, for both the Macaulay Point and Clover Point outfalls. Using the worst case effluent pH of 8.0, the information presented in Table 4.3 indicates that, in the event it is not possible to meet the pre-discharge un-ionised ammonia concentration of 1.25 mg/L, it will be possible to meet the receiving environment concentration of 0.016 mg/L. The calculated corresponding total ammonia concentration for both the Macaulay Point and Clover Point outfalls is significantly higher than what would be expected for ammonia to be present in untreated municipal wastewater. As a point of reference, the effluent pH would need to be in the order of 8.4 before there would be concerns regarding the ability to meet an un-ionised ammonia concentration of 0.016 mg/L in the receiving environment.

Table 4.3: Summary Effluent Total and Un-ionised Ammonia Concentration to Meet Chronic Conditions 100 m Away from the Outfall

Outfall Location	Effluent Un-ionised Ammonia Concentration (mg/L)	Edge of IDZ Dilution Ratio	Effluent Total Ammonia Concentration (mg/L)
Macaulay Point	≤ 3.9	245:1	≤ 146
Clover Point	≤ 2.8	175:1	≤ 104

From the above information, there are no requirements to treat for ammonia to meet the requirements of the Federal wastewater regulation. In the event that the effluent ammonia concentration is deemed to be acutely toxic, the chronic concentrations in the receiving environment can be met and, therefore, this site would be eligible to apply for a temporary authorisation, which is renewable every 3 years, if required.

5. ADDITIONAL INFORMATION – REGULATORY CHANGES

This document considers both the Federal wastewater regulation and the MWR. However, discussion is currently underway to harmonize the BC regulation with the Federal wastewater regulation, which will mean that the Federal wastewater regulation will no longer apply in BC, and the default regulation for an effluent release to a surface water will be the MWR. Preliminary discussions with the BC Ministry of Environment have indicated that, with respect to ammonia, the approach will be to focus on meeting chronic concentrations in the receiving environment, which is consistent with the current conditions in the MWR. However, this approach will need to be confirmed once the harmonization process is complete.

The timing of the harmonization agreement has not been set, but prior to the end of 2015 is considered to be reasonable.

6. SUMMARY

At this point in time, both the Federal and Provincial wastewater regulations need to be considered with respect to effluent ammonia standards. This may not be the case in the future, if the harmonization process is finalised. The default regulation will be the MWR.

The information presented above indicates that there is no requirement to reduce ammonia in order to meet the MWR. Chronic conditions at the edge of the IDZ can be met without ammonia treatment. There is also no requirement to treat for ammonia to meet the Federal wastewater regulation. There could be a slight risk that the effluent could be periodically acutely toxic for ammonia, depending on the operational

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pH. However, there is no risk that the chronic concentration would not be met in the receiving environment. Therefore, in the event that there is an issue with acute effluent toxicity, this site would be eligible to apply for a temporary authorisation, which is renewable every 3 years, if required.

Sincerely,

URBAN SYSTEMS LTD.

COLLEGE OF APPLIED BIOLOGY
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Appendix D

Options for Management of Residual Solids Memorandum

MEMORANDUM

URBAN systems

Date:	September 14, 2015
To:	Chris Town, P.Eng.
cc:	Ehren Lee, P.Eng., Steve Brubacher, P.Eng.
From:	Dr. Joanne Harkness, R.P.Bio.
File:	1692.0037.01
Subject:	Options for Management of Residual Solids

EXECUTIVE SUMMARY

Westside is currently assessing options for the management of the sanitary sewage which is produced by the area. The purpose of this memorandum is to provide an outline of the management approaches available for the residual solids which will be produced as part of the wastewater treatment process. This will include an outline of the acceptable methods of reuse and disposal, the regulatory considerations and treatment approaches. There are a variety of different words which can be used for the residual solids which are produced during municipal wastewater treatment. For the purpose of this memorandum, the use of the word “sludge” will relate to the untreated residual solids which are produced during wastewater treatment and the use of the word “biosolids” will relate to sludge which has undergone treatment and meets the regulatory standards outlined in the BC Organic Matter Recycling Regulation (OMRR).

In this memorandum, the focus for the management options was disposal to landfill, use for plant growth and use as an energy source.

With respect to disposal to landfill, it is expected that no authorisation is required from the BC Ministry of Environment as long as the receipt of the sludge/biosolids does not contravene the conditions of the landfill operating permit. The landfill owner needs to be willing to accept the sludge/biosolids. This is becoming more challenging with time, due to the diversion of organic matter away from landfills. Treatment would not be required prior to disposal to landfill, but a tipping fee will be charged.

For application to land, while this approach is long-practiced and well documented, there can be significant opposition, despite the clear benefit to plant growth and soil conditions. Treatment requirements can be costly, with little to no return on the capital and operational costs through sales opportunities. No authorisation is needed from the BC Ministry of Environment, but there is the need to register biosolids activities under the OMRR, e.g. a compost operation or a Land Application Plan. A policy statement was passed by the CRD Board indicating the desire not to apply biosolids to land.

For use as an energy source, the focus was both incineration and gasification. The common approach to using sludge as an energy source is an incineration-type process. However, this results in high capital and operational costs, which could include the need to dry the sludge before combustion in order to increase process efficiency. There are risks associated with the gasification process, as this approach is relatively new for sludge/biosolids management and, as such, there is little information on the long-term operation. Moisture content and calorific value are both important when considering process efficiency. There is a risk with respect to the authorisation requirements, until incineration and gasification of sludge/biosolids becomes established in BC. From the information available, it is expected that no authorisation is needed from the BC Ministry of Environment for the development of a combustion process for sludge/biosolids. Depending on the management approach for the waste solids and any wastewater which may be produced as a result of combustion, it is possible that no further authorisations are needed from the BC Ministry of Environment, with the only authorisation being a permit for air emissions. There is also a risk with respect to the requirement of a BC environmental assessment, although this may be avoided, depending on interpretations regarding the material for combustion and wording in the approved CRD Liquid Waste Management Plan. Clarification on these interpretations would be required from the BC Environmental Assessment Office.

1. INTRODUCTION

Westside is currently assessing options for the management of the sanitary sewage which is produced by the area. The purpose of this memorandum is to provide an outline of the management approaches available for the residual solids which will be produced as part of the wastewater treatment process. This will include an outline of the acceptable methods of reuse and disposal, the regulatory considerations and treatment approaches.

2. TERMINOLOGY

There are a variety of different words which can be used for the residual solids which are produced during municipal wastewater treatment. For the purpose of this memorandum, the following terminology and definitions will be used:

Sludge: The excess organic solids which are produced as a result of treating liquid wastes at wastewater treatment plants. These solids consist primarily of the excess micro-organisms which are used to treat wastewater. Sludge has not been treated by any recognised solids treatment process in order to produce biosolids. Therefore, the health and environmental risks associated with sludge can be high. Common concerns with sludge are the production of strong malodours, illness and environmental contamination.

Biosolids: Wastewater sludge which has been treated in order to create a product which has a lower pathogen concentration and is stable organically. The treatment processes to produce biosolids can result in a final product which has low risks to human health and the environment. Concerns relating to the production of strong malodours, illness and environmental contamination are low with biosolids.

3. OPTIONS FOR DISPOSAL AND REUSE

There are three common options for the management of sludge and biosolids. These options are:

1. Disposal
2. Use for plant growth
3. Use as an energy source

These three options are outlined in greater detail below.

3.1 Disposal

There are two approaches to the disposal of sludge/biosolids: landfill or incineration. With respect to landfill, the intent is that the sludge/biosolids will be incorporated into the landfill as waste material, rather than being used for cover. There are three different types of cover used at a landfill: daily cover, intermediate cover and final cover. However, there is a perception that if sludge/biosolids are used for daily cover, or even in some cases intermediate cover, then this should be classified as disposal, rather than a use. There is general agreement that use of sludge/biosolids for final cover is beneficial and should not be considered as disposal. With respect to incineration, in the event that sludge/biosolids are incinerated without any intent for energy recovery, this should be considered disposal and not use. For the purpose of this discussion, any consideration for disposal will focus solely on landfilling, rather than incineration, as it is assumed that if incineration is selected as a suitable opportunity for Westside, then this would be accompanied by energy recovery.

Generally, the disposal of sludge/biosolids to landfill does not need any direct authorisation or approval from the BC Ministry of Environment. The ability for a landfill to receive sludge/biosolids is typically authorised under general operating conditions through a permit or operational certificate, which is issued by the BC Ministry of Environment. The general operating conditions for landfills typically include restrictions relating to accepting wastes that are liquid in nature. Therefore, only dewatered sludge/biosolids can be received at a landfill. Although no strict number is given with respect to the desired solids content of sludge/biosolids for disposal to landfill, a good rule of thumb is a minimum of 12% for solids content, as this material can be handled as a solid. A solids content of 12% can be easily achieved by more simple dewatering processes, however, the standard dewatering process (i.e. the centrifuge) typically achieves a solids content in the order of 20%. Wording in the operational certificate for the Hartland Landfill does not expressly recognise sludge or biosolids, with the exception of the composting operation, which indicates that digested sewage sludge can be composted at this site.

The receipt of sludge/biosolids at landfill sites will incur trucking costs and tipping fees. Moisture content associated with the sludge/biosolids is an important factor with respect to both of these costs. A wetter sludge/biosolids will result in higher trucking and tipping fees, so there is an advantage to achieving a higher solids content during dewatering.

It is not necessary to treat the sludge to create biosolids before disposal to landfill. Treatment to create biosolids would help control odours and reduce the presence of potential pathogens. While odours associated with sludge may be a concern, odours are naturally associated with the material which is disposed to landfill and the use of daily cover is implemented as standard practice, regardless of whether sludge is present, to help control nuisance conditions, including odour. There is also a low concern with respect to human contact and the potential pathogens present in the sludge, due to the nature of a landfill operation. Treatment to create biosolids from sludge would incur costs, and the benefits associated with this capital and operational expenditure are questionable for a disposal practice. There could also be issues with perceptions regarding the disposal of biosolids, compared with sludge, as discussed below.

There is an increasing desire to divert organic matter from landfills. For example, the City of Calgary has banned the disposal of organic matter to landfill. The first phase of this policy will come into effect in 2017 with a complete ban to be effective 2019. Diversion of traditional waste into use is not just being encouraged from the local level, but is also being directed by Provincial and Federal policy. In 2012, the development of the Biosolids Management Strategy through the Canadian Council of the Ministers of the Environment (CCME) set policy throughout Canada to encourage the development of beneficial use approaches for sludge and biosolids, rather than disposal. This direction was fully embraced by the BC government. The CCME biosolids strategy highlighted the potential valuable nature of biosolids and the need to conserve landfill space for materials which truly do require disposal. As such, the document provided direction and outlined the desire for sludge to be treated to create biosolids, which could then be available for beneficial use. It is becoming harder to dispose of sludge/biosolids to landfill, and it is possible that this option may be eliminated in the future.

Although it may be possible to dispose of dewatered sludge/biosolids to landfill, it is necessary for the landfill owner to agree to accept the material. For many communities, this can be challenging as the sludge/biosolids provider is often different to the landfill owner. However, in this case, the CRD would bear responsibility for both sludge/biosolids production and landfill operations. Therefore, the ability to co-ordinate these two operations could easily be facilitated.

The advantages and disadvantages of disposing sludge/biosolids to landfill are summarised in Table 3.1.

Table 3.1: Advantages and Disadvantages of Disposal to Landfill

Advantages	Disadvantages
No need to incur costs to treat to create biosolids. Treatment is limited to dewatering only.	Approach is inconsistent with Federal and Provincial policy to encourage reuse not disposal.
Costs are limited to dewatering, trucking and tipping fees.	Potential to be short-term option only, due to desire to divert organic waste from landfills.

Table 3.1: Advantages and Disadvantages of Disposal to Landfill *(continued . . .)*

Advantages	Disadvantages
No authorisations needed – only an agreement from the landfill operator.	Using dewatered sludge for daily or intermediate cover may not address odour issues.
High potential to amalgamate sludge/biosolids and landfill operations as the CRD will be responsible for both activities.	There could also be issues with the dewatered sludge/biosolids becoming slippery when wet, due to the use of polymer for dewatering. This could affect the desire to use sludge/biosolids for daily or intermediate cover.

To summarise for the approach of disposal to landfill:

1. The landfill owner needs to be willing to accept the sludge/biosolids. This should be relatively easy to reach an agreement on, given that the CRD will be responsible for both sludge/biosolids and landfill operations.
2. It is expected that no authorisation is needed from the BC Ministry of Environment, but the receipt of sludge/biosolids is not to contravene any requirements in the operating permit or certificate for the landfill. The typical concern relates to liquid content, but this can be overcome through dewatering. Dewatering will be required to an approximate minimum solids content of 12%.
3. No treatment is required to produce a biosolids. This presents a capital and operational cost savings. It is relatively acceptable to dispose sludge to landfill but the production of biosolids could cause complications due to the concept that biosolids are a higher quality than sludge and, therefore, are more suitable for reuse than disposal.
4. A tipping fee will be charged.
5. The sludge/biosolids may be used as daily or intermediate cover, but this is not necessarily the case. It is possible for this material to be incorporated directly into the landfill, with waste matter.

3.2 Use for Plant Growth

This is the main approach to sludge and biosolids management throughout the world, and recognises the nutritional value that this type of organic matter can provide to plant life.

Although there are policy guidelines published by the CCME to encourage the use of biosolids in Canada, there are no Federal regulations governing the use of biosolids. In 2002, the Province of BC promulgated the Organic Matter Recycling Regulation (OMRR), which is intended to facilitate the management of septage, sludge and biosolids to encourage use, rather than disposal. The OMRR outlines the practices for the acceptable treatment and application of organic matter to land for plant growth. There are three aspects to the OMRR:

1. Quality requirements
2. Treatment requirements
3. Requirements for the application to land

All three aspects are important when considering the requirements for the use of biosolids and biosolids products to land.

3.2.1 Quality Requirements

Under the OMRR, organic matter is separated into five different categories:

- Class A compost;
- Class B compost;
- Class A biosolids;
- Class B biosolids; and,
- A biosolids growing medium.

Table 3.2 summarises the quality of the 5 organic products which are identified in the OMRR. Biosolids growing medium and Class A compost have the highest quality. These products have no restrictions regarding their uses or access by the public. The quality requirements for a biosolids growing medium are higher than a Class A compost, as a biosolids growing medium is intended to be used in place of a soil. A Class A compost is intended to be used as an organic amendment and blended with soil to enhance soil nutrient content. A Class A biosolids is still a high quality product, and is intended to be blended with soil to enhance soil nutrient content. For quantities less than 5 m^3, the conditions for use of a Class A biosolids are exactly the same as those for a biosolids growing medium and a Class A compost, with no use or access restrictions. However, there are constraints on the use of Class A biosolids when the intent is to use more than 5 m^3 per year per parcel of land. The lowest quality categories apply to a Class B compost and Class B biosolids, and the use of these materials is subject to a number of constraints. In both cases, these biosolids products are intended to be blended with soil to enhance the soil nutrient content.

Table 3.2: Summary of Material Quality under the OMRR

Parameter	Medium Type				
	Biosolids Growing Medium	**Class A Compost**	**Class B Compost**	**Class A Biosolids (Note 1)**	**Class B Biosolids**
Access	Unrestricted	Unrestricted	Restricted	Some restrictions	Restricted
Foreign Matter Content (% dry weight)	< 1	< 1	<1	<1	< 1
Sharp Foreign Matter	None present	None present	None present	None present	None present
C:N Ratio	> 15:1	> 15:1 and < 35:1	N/A	N/A	N/A
Faecal Coliforms (MPN/g dry weight)	< 1,000	< 1,000	< 2,000,000	< 1,000	< 2,000,000
Maximum Element Concentration (µg/g dry weight)					
Arsenic	13	13	75	75	75
Cadmium	1.5	3	20	20	20
Chromium	100	100	1,060	1,060	1,060
Cobalt	34	34	150	150	150
Copper	150	400	2,200	757	2,200
Lead	150	150	500	500	500
Mercury	0.8	2	15	5	15
Molybdenum	5	5	20	20	20
Nickel	62	62	180	180	180
Selenium	2	2	14	14	14
Zinc	150	500	1,850	1,850	1,850

Note 1: The quality criteria for a Class A biosolids is based on Federal requirements, stated in the Trade Memorandum T-4-93. This trade memorandum has no standards for copper or chromium, both of which are important for biosolids and biosolids products. The values stated in Table 3.2 for these metals are the proposed standards which have been indicated as reasonable by the BC Ministry of Environment.

3.2.2 Treatment Requirements

The treatment requirements under the OMRR relate to pathogen reduction and vector attraction reduction. Pathogen reduction is the decrease in micro-organisms which may have the potential to cause illness or disease and vector attraction reduction is the reduction in the potential for nuisance conditions (e.g. odour, attracting flies, etc.).

The requirements for pathogen reduction are outlined in Schedule 1 of the OMRR and are based on a temperature-time relationship for the destruction of enteric micro-organisms. The temperature-time relationship allows for either short periods of time when the sludge is exposed to elevated temperature or long periods of time when the sludge is exposed to low or ambient temperatures. The higher quality biosolids products (i.e. a biosolids growing medium, Class A compost and Class A biosolids) all require a period of elevated temperature (i.e. ≥ 50 ^{o}C) for an enhanced pathogen destruction to be achieved. Class B products (i.e. Class B biosolids and Class B compost) only require low or ambient temperature conditions, with the result being that there will likely be higher concentrations of potential pathogens associated with a Class B biosolids product.

From Schedule 1 of the OMRR, a biosolids growing medium or a Class A biosolids product can be achieved using a digestion process (aerobic or anaerobic digestion or composting) under elevated temperature conditions. The high temperature digestion processes are the most common approach for sludge treatment to create a biosolids product. Aerobic or anaerobic digestion normally requires an external energy source to achieve the elevated temperatures, but composting will achieve these temperatures naturally, as long as the organic matter is highly biologically active. The OMRR also recognises the potential to produce a Class A biosolids/biosolids growing medium by the addition of a highly alkaline substance, which will cause the temperature and pH to be raised. Treatment with the highly alkaline substance is not sufficient on its own to create a Class A biosolids/biosolids growing medium. Once treated, the biosolids must then be air dried to a minimum solids content of 50%. Lime is the most common alkaline substance which is used for sludge treatment. The wording in Schedule 1 of the OMRR also allows for any heat treatment method to be recognised as suitable to create a Class A biosolids/biosolids growing medium, as long as certain temperature conditions are met for a specified length of time. This wording in the OMRR was intended to allow the future inclusion of treatment processes which either were not developed or were not being used for sludge treatment at the time of the development of the regulation.

The acceptable processes to produce a Class B biosolids or a Class B compost are similar to those outlined for the Class A products (i.e. namely aerobic or anaerobic digestion, composting or lime stabilisation), however, the temperature-time requirements are less stringent. There are two further differences to the acceptable treatment processes for a Class B product: there is no requirement for air drying after treatment with lime, and air-drying on open beds under ambient temperature conditions is recognised as an acceptable treatment process.

Vector attraction reduction is the process by which the organic matter undergoes a change which will result in a biosolids or compost having low biological activity and a low odour potential. The acceptable vector attraction reduction methods are outlined in Schedule 2 of the OMRR and, unlike the pathogen reduction processes, there is little difference between a Class A and a Class B treatment process. The most common methods of vector attraction reduction involve biodegradation (i.e. composting and aerobic or anaerobic digestion). However, the use of an alkaline substance to increase the pH to the pH 11 to 12 range and the drying the sludge to at least 90% solids content are also acceptable treatment processes in the OMRR. However, in both of these cases, the treatment process does not destroy the organic matter but simply creates conditions which are not conducive to microbial activity. Should the conditions change either by a decrease in the pH or if the biosolids should become wet, it microbial activity can commence and nuisance conditions could be created. Therefore, unlike a digested/composted product, it is important that a pH-treated or dried product is handled carefully and appropriately in order to avoid nuisance conditions. In the case of the dried product, the OMRR does state that there is a requirement to maintain the dryness of the biosolids until application to land. This is to avoid nuisance conditions during storage.

The OMRR does identify alternatives to implementing one of the recognised treatment processes for vector attraction reduction. These alternatives are:

1. Laboratory testing to prove that there is low, or the potential for low, biological activity associated with the organic matter. The approach to this testing is open-ended, allowing flexibility within the regulation and emerging processes, technologies and analyses.
2. If the product does not meet the Class B biosolids or a Class B compost requirements, then the organic matter can still be applied to land for beneficial use as long as the risks associated with an unclassified product are managed through the land application practices, such as direct sub-surface injection or tilling into the soil within a short period of time.

3.2.3 Requirements for Application to Land

Under the OMRR, organic matter can be used to enhance vegetation or plant growth. There is a whole range of different types of lands where biosolids and biosolids products could be used, including back yards, community parks, agricultural lands, forestry lands and the rehabilitation of disturbed lands, such as mines, gravel pits and landfills. In the case of landfills, as indicated above, the use of biosolids/biosolids products for final cover to enhance rehabilitation of the land is perceived as a beneficial use, whereas use for daily and intermediate cover is perceived as disposal and is discouraged. The type of biosolids or biosolids product is important when developing direction for application to land.

A Class A compost, a biosolids growing medium and a Class A biosolids (for volumes less than 5 m^3/parcel of land) can be used without restriction. As such, it is possible for these types of products to be used in back yards, community parks as well as the standard approaches to application such as agricultural land and the rehabilitation of disturbed lands. However, there are more restrictions for a

Class B compost, a Class B biosolids or larger volumes of Class A biosolids, and a Land Application Plan is required in each case. The Land Application Plan is to be prepared by a qualified professional and submitted to the BC Ministry of Environment before the organic matter is used. The Land Application Plan outlines appropriate application methods, timing, weather conditions, crop and soil needs, testing and monitoring requirements, and site-specific precautions which are needed.

Although the OMRR focuses on allowing the land application of biosolids or biosolids products which have met both treatment and quality requirements, it is possible for sludge to be applied to land, even if the sludge does not meet all of the quality or treatment criteria outlined in the OMRR. In this case, additional testing or site specific controls or application methods would likely be needed in order to protect public health and the environment.

3.2.4 Discussion on Land Application

The land application of biosolids and biosolids products is a controversial subject with many prejudices, misunderstandings and concerns. On the positive side, the use of biosolids and biosolids products for the enhancement of plant growth has been a practice throughout the world for many centuries. There is a clear nutritional benefit to the use of these products, with advantages including:

- The nutrients present in biosolids and biosolids products provide a good balance of macro and micro-nutrients, organics and minerals – i.e. the full package needed for plant growth.
- The use of biosolids and biosolids products will reduce, and may even eliminate, the need for chemical fertilizers.
- Biosolids and biosolids products will allow for a slow release of the nutrients over time, which reduces risk associated of a fast flush of nutrients through the soils. The fast flush of nutrients is often associated with rainfall/irrigation after a period of dryness and is related to the inability of the plants to take up the excess nutrients which have been applied to the soil through a heavy fertilizer application. The flushing of nutrients through the soil raises risks with respect to run-off and groundwater contamination. The slow release of nutrients from biosolids/biosolids products also allows for the nutrients to be used by the plants throughout the growing season.
- The organic nature of biosolids and biosolids products can result in improved soil structure and increase the ability of the soil to hold water. This increases in importance in dry conditions as it can result in the need for less watering.

The use of biosolids and biosolids products for the enhancement of plant growth is regulated by the OMRR, which was developed based on scientific information. The treatment, quality and application of the biosolids and biosolids products are all controlled, which provides the ability to manage health and environmental concerns. By comparison, there is no control over the use of manures, which could contain significant concentrations of pathogens, heavily metals or medications used in agricultural processes, and there is no control over the use of chemical fertilizers, which can easily be misused or over-applied. From this, there could be both health and environmental impacts as a result of using manures or fertilizers, due to the lack of control.

However, concerns are raised with the use of biosolids and biosolids products. Some of these concerns relate to misunderstandings, but some are valid. Some of these concerns are discussed in further detail below.

It is possible that malodours could be caused as a result of biosolids and biosolids products, with the risk of odours being greater for a Class B or Class A biosolids, compared with a compost or biosolids growing medium. The cause of the odours is related to the continued self-digestion of the biosolids/biosolids product during storage and will become a higher risk during prolonged storage of large stockpiles. Although similar odours can be associated with manures, there is a perception that manure odours are acceptable, but an odour which results from biosolids/biosolids products is not acceptable. The risks associated with odours can be managed through increased treatment (vector attraction reduction), storage conditions and application conditions. However, one unfortunate factor is that a little odour can travel a long way and, once neighbours become aware of a disagreeable odour, there is an increased sensitivity to even slight odour conditions.

Biosolids and biosolids products can be seen as human waste and, therefore, are automatically perceived as being toxic to human health and the environment. There are many misquotes where biosolids and biosolids products are described as human sewage. There is a lack of understanding that biosolids and biosolids products are not sewage, but are the excess micro-organisms which are used to treat sewage and most of these micro-organisms are found naturally in the environment, e.g. a wetland or in lake sediments, but have simply been concentrated as part of the sewage treatment process. There is also a lack of understanding of the treatment to create a biosolids/biosolids product and that there is a difference between biosolids and sludge. However, while it should be recognised that biosolids and biosolids products are not sewage, they are created from sewage and components of that sewage could affect the quality, with three key concerns being pathogens and the presence of pharmaceuticals and heavy metals.

Pathogens or micro-organisms which could cause illness or disease will be present in sewage and may also be present in the sludge, biosolids or biosolids products. This is no difference to similar micro-organisms being present in manures which are also used to enhance plant growth. These micro-organisms can be treated, as indicated in the various pathogen reduction processes for Class A and Class B standards, but they are also at a disadvantage to surviving during the sewage treatment process or in soils, as their natural environment is the digestive system. In addition, other considerations such as direct contact, ingestion and the need to be in contact/ingest a certain number of specific disease-causing organisms is required before illness or disease can occur. The presence of pathogens or micro-organisms which could cause illness or disease are regulated under the OMRR.

Pharmaceuticals or other similar substances are present in sewage and the concern is that these substances can interfere with the endocrine system. The best documented effect is the feminisation of male species as a result of contact with female hormones which are present in sewage effluents. The challenge with these substances is that they are only found in trace amounts and are difficult and expensive to analyse for. Some of these substances remain associated with the effluent and should not be considered as a concern for the land application of biosolids or biosolids products. However, some of these substances adhere to sludge and will be present during land application. Scientific research has indicated that these substances prefer to remain associated with the biosolids, which lessens the concern that they have the ability to migrate through soils to contaminate the environment. Scientific research has also indicated that by being associated with biosolids/biosolids products, this increases the potential and rate at which these substances are broken down biologically. The presence of pharmaceuticals and similar substances is not regulated under the OMRR. This is largely due to several factors such as the emerging nature of this topic, challenges with analysis and detection, and the extremely low concentrations in which these substances are found. Pharmaceuticals and other similar substances can also be present in manures.

Heavy metals are present in sewage and have a natural tendency to migrate to and accumulate in the sludge. Therefore, heavy metals will be present in biosolids and biosolids products. While heavy metals can be used as trace nutrients, there is a concern with contamination and, although heavy metals prefer to be associated with sludge/biosolids/biosolids products, it may be possible for them to become soluble and move through soils, potentially entering groundwater and surface water. The presence of heavy metals is regulated under the OMRR, with standards including pre-application concentrations and post-application concentrations, which also consider the presence of heavy metals in soils and the need to protect health and the environment. Heavy metals are also found in manures and commercial fertilizers, and there is limited ability to regulate or control activities related to the application of manures and commercial fertilizers.

Sludge, biosolids and biosolids products are also perceived to be associated with pollution. However, commercial fertilizers and the use of manures can also cause pollution if used in the wrong place at the wrong time. Unlike commercial fertilizers and the use of manures, there are strict controls over the use of sludge, biosolids and biosolids products in order to reduce the risk that pollution could occur.

With respect to the CRD, there is an additional roadblock relating to the application of waste organic solids from a wastewater treatment plant to land – a policy statement was passed by the CRD Board indicating the desire not to apply biosolids to land.

The advantages and disadvantages of using sludge/biosolids and biosolids products to enhance plant growth are summarised in Table 3.3.

Table 3.3: Advantages and Disadvantages of Land Application

Advantages	Disadvantages
Provide valuable nutrients to enhance plant growth and soil conditions.	Treatment to develop a high quality product is costly and will not be realised through sales.
Can result in less water usage.	Costs incurred could also include trucking to the application site, the Land Application Plan (development, monitoring and reporting) and the physical application.
Can result in less commercial fertilizer use.	Public perception, concerns and fears can result in challenging situations and strong bias against land application.
Can reduce risks to the environment as a result of the slow release of nutrients.	A policy statement was passed by the CRD Board indicating the desire not to apply biosolids to land.
Strict controls for treatment, quality and application.	Lower quality products can result in limitations to their use – i.e. only available use is application to agricultural lands, forestry lands or disturbed lands.
High quality products can be sold, with some cost recovery and many potential outlets, including back yards and municipal projects. High quality products can have very high support from members of the community.	

To summarise for the approach of use for land application:

1. The land application of sludge, biosolids and biosolids products has been practiced throughout the world for centuries, with clear benefit to plant growth and soil conditions.

2. The higher quality products can be used without restrictions and could be sold. The lower quality products require greater control and there is no real opportunity for sale of the product.

3. There are treatment, quality and application requirements in the OMRR. The higher the quality of the product, the greater the treatment requirement, which could be costly with little return on these costs through sales. However, treatment is not always necessary and it is possible to land apply a sludge, but this may require additional testing and more stringent application controls.

4. No authorisation is needed from the BC Ministry of Environment, but there is the need to register biosolids activities under the OMRR, e.g. a compost operation or a Land Application Plan.
5. There could be significant public opposition to land application, due to misconceptions, prejudice and misunderstandings. This opposition may be less if a Class A compost or biosolids growing medium is developed, which could be given away or sold to members of the public. However, with the large volume of product which could be available in the local area, there is also a risk that the market for individual sales could be saturated, leaving a potential stockpile with limited additional opportunities for use.
6. A policy statement was passed by the CRD Board indicating the desire not to apply biosolids to land.

3.3 Use as an Energy Source

3.3.1 Introduction to Incineration and Gasification

This approach considers the use of processes such as incineration and gasification where organic matter undergoes combustion in order to produce heat and the potential ability to generate electricity. Incineration is the heating of organic matter using excess oxygen. The sludge does not have to be dry before it is fed into the incinerator, although a higher moisture content will result in an increased need for supplemental fuel. Incineration has been used as a means of sludge management throughout the world for several years. In Switzerland, incineration is the only acceptable approach to sludge management. The basic principle of gasification is to convert organic matter into gases (syngas) which can then be used as a fuel source. Unlike incinerators, gasifiers require the feed organic matter to have a low moisture content (e.g. only 10 to 20%). Although gasification has been used to produce energy from coal for over 200 years, gasification is a relatively new technology with respect to sludge management and, as such, there is limited information available on the performance of full-scale units. Gasification has the potential to be a successful approach to the management of sludge/biosolids, but there is a level of uncertainty and the need for sufficient information to prove the viability of this process.

3.3.2 Operational Considerations

The organic content of the sludge/biosolids is a suitable potential alternative or additional energy source for incinerators or gasifiers. Organic matter and moisture content are both important when considering diverting sludge/biosolids to use as an alternative energy source. The highest calorific value will be achieved for an organic material which has a high organic matter and low water content.

With respect to the organic matter, the highest calorific value will be associated with a young sludge. Treatment for vector attraction reduction through composting or aerobic/anaerobic digestion or even a simple long-term storage of sludge will result in the biological degradation of the organic matter into a more stable product. This will lower the calorific value. Therefore, unless concerns are raised regarding nuisance conditions such as odours, there is no advantage to treating sludge to create a biosolids/biosolids product if the intent is to use the organic matter as an energy source. (Note that the odours relate to operator considerations at the incineration/gasification site, rather than a nuisance factor to surrounding properties, as the odours can be contained and foul air treated before release.) Avoiding the need for treating sludge will also avoid the additional capital and operational costs which are incurred to create a biosolids or biosolids product. There is an additional concern with respect to allowing biological degradation of the sludge before incineration/gasification. The action of biological degradation will also reduce the amount of organic matter which is available for burning. This could result in the inability to provide sufficient organic matter to allow the efficient operation of an incinerator/gasifier.

With respect to the water content, although a sludge/biosolids does not have to have significant water removed before it can be considered as a suitable energy source, the drier the material the higher will be the calorific value and ease of handling, especially with respect to the feed conveyor. For incinerators, it is possible that a solids content as low as 15% could be suitable, but this would require a sufficient balance with dry material being fed into the energy recovery process. It is important that this balance is maintained, as the potential result could be the need to supplement the heating process with propane or electricity. The direction is to improve process efficiency by seeking approaches which will further increase the solids content from the standard 20 to 30% range through to the 35 to 50% range. Incinerators are more flexible for operation with a higher moisture feed, compared with gasifiers, where drying to a solids content in the 85 to 93% solids content is required. Pre-drying of the sludge is possible and can be assisted by capturing and recycling heat generated from the combustion process. The ultimate goal for combustion processes is to produce energy which could be sold, but the reality is to aim for a process which will produce sufficient energy to cover the operational requirements. For the information which is available on sludge incinerators which have been in operation for a number of years, in some cases, this goal is not even met.

3.3.3 Regulatory Considerations

In theory, the use of sludge or biosolids/biosolids products as an alternative energy source does not need any direct authorisation or approval from the BC Ministry of Environment, but any emissions do need to be authorised. The products from a combustion process include gases, heat, a solid waste and, in some cases, a liquid waste stream. Authorisations for gases, solid waste and the liquid stream need to be considered, with no further consideration for the produced heat, as it is assumed that this would be recirculated within the facility to increase process efficiency.

The release of gases will require a permit from the BC Ministry of Environment for air quality emissions. This would include the need for studies to determine the movement of contaminants within the airshed and the potential for environmental and health impacts. As this process is approval by permit, there is the need to include public consultation. There could be complications with respect to public input and the release of gases due to the potential for toxic substances to be present in the emissions.

The solid waste could be regarded as a potential beneficial product which could be applied to land to enhance plant growth, especially with regards to the ash being a valuable source of phosphorus. It may be possible to register this activity under the OMRR, however, this would require discussion with the BC Ministry of Environment as the definitions in the OMRR are not necessarily clearly aligned with the nature of the solid waste. There could be regulatory challenges as to how land application of the solid waste could be authorised or approved. The solid waste could also have the potential to be incorporated into building materials, such as bricks and asphalt. As a result of the combustion process, metals become concentrated in the waste solids and, in some instances, this has resulted in the solids being regarded as a toxic waste which requires disposal to landfill or even a special disposal site for contaminated waste. Disposal to an authorised site would not necessarily need approval from the BC Ministry of Environment, but must not contravene the requirements of the landfill permit or operational certificate.

The liquid stream would only need to be authorised by the BC Ministry of Environment if it is to be released to the environment, either with or without on-site treatment. As this liquid stream is no longer considered to be sewage, this authorisation would likely be under a permit. The release of the liquid stream to the sanitary sewer system would need agreement with the local municipality and would need to comply with any sewer by-laws and the quality standards outlined in the BC Hazardous Waste Regulation. By receiving the liquid stream, it is the responsibility of the local municipality to ensure that there are no detrimental impacts on the sanitary sewer system or effluent quality.

There is also the risk that an energy source solution could trigger the BC Environmental Assessment Act. This risk increases if the immediate intent is to co-combust sludge/biosolids with municipal solid waste. Sludge and biosolids typically fall under the definition of “municipal liquid waste”, rather than “municipal solid waste” and, therefore, are dealt with under the Liquid Waste Management Plan process, rather than the Solid Waste Management Plan process. If the immediate intent is to use the incinerator or gasifier to combust only sludge/biosolids, the resulting project could be seen as a local government liquid waste management facility. Under the BC Reviewable Project Regulation local government liquid waste management facilities do not require a BC environmental assessment as long as the facility is part of an approved Liquid Waste Management Plan.

3.3.4 Discussion

The advantages and disadvantages of using sludge/biosolids as an alternative energy source are summarised in Table 3.4.

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Table 3.4: Advantages and Disadvantages of Use as an Alternative Energy Source

Advantages	Disadvantages
Ability to generate energy.	Uncertainties regarding authorisations until these processes become more established in BC, including interpretations which require input from the BC Ministry of Environment and the BC Environmental Assessment Office.
Ability to utilise the excess heat generated by the combustion.	Public perception on air emissions can be poor and controversial.
Possibility of developing an energy neutral process which will allow for the recovery of operational costs.	Permitting for air emissions can be lengthy and require complex technical information on airshed conditions.
Good documentation on incineration process for sludge in Europe, including approaches to optimise.	Uncertainties regarding waste solids from combustion process – may be classified as toxic waste.
Ability to avoid capital and operational costs for pathogen reduction and vector attraction reduction.	High capital and operational costs for incinerators.
If disposal of combustion solid waste is required, this will have lower trucking and tipping costs compared with raw sludge, due to moisture and volume reduction.	Energy production may not cover energy requirements.
Lower footprint requirements compared with traditional processing of sludge for land application (such as anaerobic/aerobic digestion and composting).	Risk with gasification as relatively new process for sludge/biosolids management.
Potential for waste solids (ash) to be used as a fertilizer or valuable source of phosphorus for land application.	

To summarise for the approach of use as an energy source:

1. The common approach to using sludge as an energy source is an incineration-type process. However, this results in high capital and operational costs, which could include the need to dry the sludge before combustion in order to increase process efficiency.
2. There are risks associated with the gasification process, as this approach is relatively new for sludge/biosolids management and, as such, there is little information on the long-term operation.
3. The process efficiency is dependent on the calorific value and moisture content of the sludge. There is no advantage to treating the sludge to create biosolids or a biosolids product, unless there are concerns from the site operators regarding odours. As the odours can be contained and managed, there is no concern with respect to nuisance conditions for neighbouring properties.
4. There is a risk with respect to the authorisation requirements, until incineration and gasification of sludge/biosolids is established in BC. From the information available, it is expected that no authorisation is needed from the BC Ministry of Environment for the development of a combustion process for sludge/biosolids. Depending on the management approach for the waste solids and any wastewater which may be produced as a result of combustion, it is possible that no further authorisations are needed from the BC Ministry of Environment, with the only authorisation being a permit for air emissions. There is also a risk with respect to the requirement of a BC environmental assessment, although this may be avoided, depending on interpretations regarding the material for combustion and wording in the approved CRD Liquid Waste Management Plan. Clarification on these interpretations would be required from the BC Environmental Assessment Office.

4. SUMMARY

There are three common options available for the management of sludge. These options are: disposal to landfill, use for plant growth and use as an energy source. Figure 4.1 summarises the potential for these options with respect to sludge. For disposal to landfill and use for energy recovery, treatment to create biosolids or a biosolids product is not required. In fact, such treatment would be of detriment to the proposed management option through the perception that biosolids is a product which should have a beneficial use and should not be disposed to landfill, and the reduced organic matter as a result of treatment will lower the calorific value and the amount of organic matter available for combustion, both of which are essential to maximise the energy recovery process. Although it is possible to apply a sludge to land for plant growth, the preferred route would be to treat the sludge to create biosolids or a biosolids product. The treatment options and the resulting type of organic matter produced are summarised in Figure 4.2. These treatment options are all recognised in the OMRR, although the regulation does include flexibility to acknowledge additional processes, depending on the technical information which is available.

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The following authorisations and approvals would be needed for each management option:

Disposal to landfill	No approval needed from the BC Ministry of Environment as long as this is in accordance with the permit or operational certificate. Agreement would be needed with the landfill owner.
Use for plant growth	Registration under the BC OMRR.
Use as an energy source	There is a risk with respect to the authorisation requirements, until incineration and gasification of sludge/biosolids is established in BC. Clarification on regulatory interpretations would be required from both the BC Ministry of Environment and the BC Environmental Assessment Office.
	Permit required from the BC Ministry of Environment for air emissions.
	No approval needed from the BC Ministry of Environment for disposal of solids to landfill, as long as this is in accordance with the permit or operational certificate. Agreement would be needed with the landfill owner and solids may have to be disposed at a special site for contaminated waste.
	Use of waste solids on land could be registered under the OMRR, but discussion required with the BC Ministry of Environment on whether this is possible or if another authorisation route is needed.
	Liquid stream could be released to sanitary sewer – will require agreement with local sanitary sewer owner and will need to meet by-law and BC Hazardous Waste Regulation requirements. If approach is to treat and release, this will need authorisation by BC Ministry of Environment, likely under a permit.

Sincerely,

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Appendix E

Pump Station Cost Curves

Sewage Lift Stations

PIR Base Asset Code:

C2 Sewage Lift Stations <500 L/s

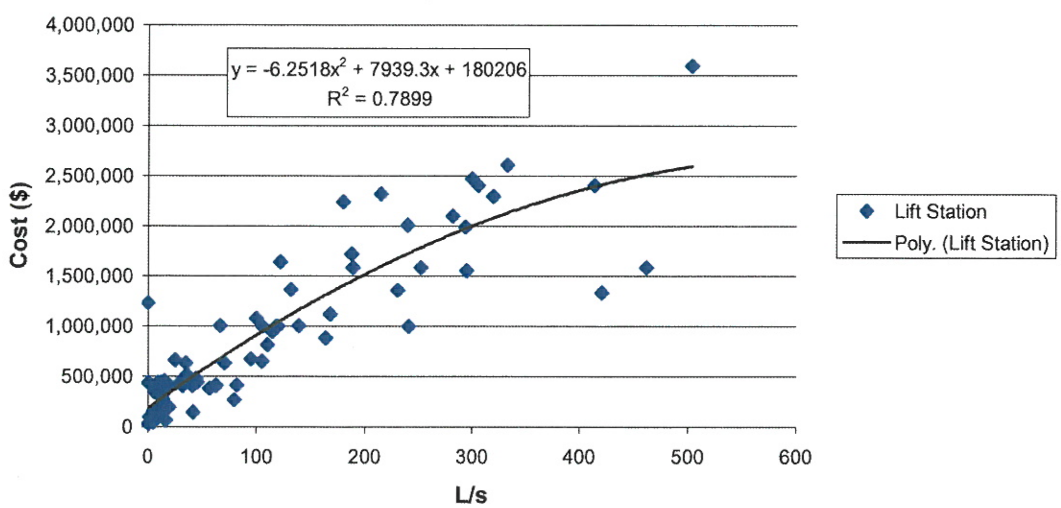
Capacity Measure:

Capacity of the wastewater pumps in L/s

Equation: <500 L/s $y = -6.2518x^2 + 7939.3x + 180206$

R^2: <500 L/s 0.7899

C2 Lift Station <500 L/s



Assumptions and Comments:

- Combined General Multiplier = 1.33 (to be added to base cost curve)
- Costs associated with this asset include the wastewater pumps, manhole structure and associated mechanical and electrical components
- Breakpoint identified at +/- 500 L/s

Sewage Lift Stations

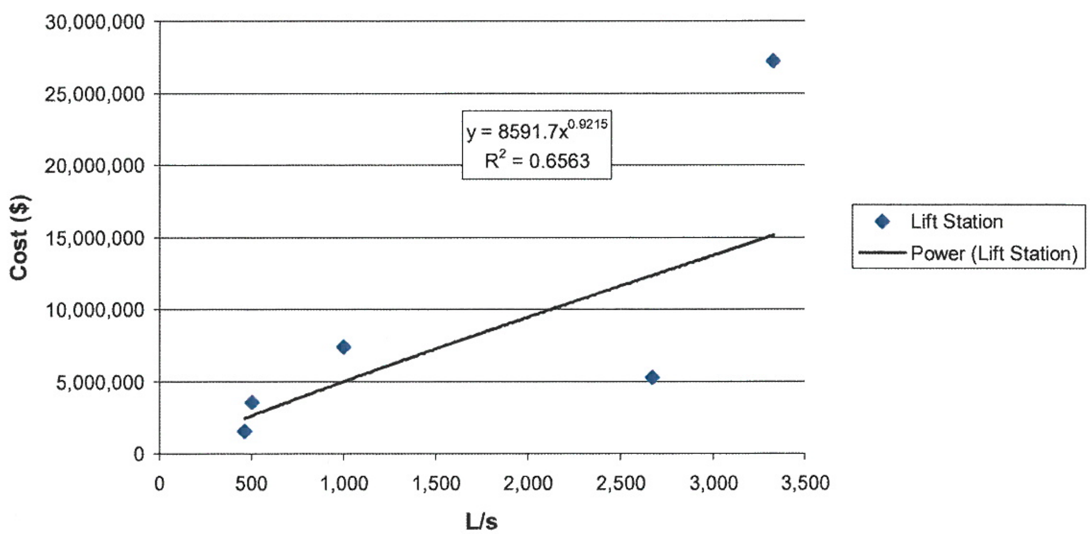
PIR Base Asset Code:
C2 Sewage Lift Stations >500 L/s

Capacity Measure:
Capacity of the wastewater pumps in L/s

Equation: >500 L/s $y = 8591.7x^{0.9215}$

R^2: >500 L/s 0.6563

C2 Lift Station >500 L/s



Assumptions and Comments:
- Combined General Multiplier = 1.33 (to be added to base cost curve)
- For additional comments see C2 < 500 L/s

Appendix F

Updated Site Prioritization

Appendix F – Updated Site Prioritization

Site Number	Site Name	Estimated Usable Area (ha)	Comments	Conclusion
1	Langford VMP at Kelly Road	1.85	By way of comparison to Site 2a there is no appreciable advantage and Site 2a is closer to the trunk sewer. It is not close to another piece of property that could be combined with it.	Not Preferred
2a	Langford VMP at Meaford Avenue	1.89	This site is in Langford, is large enough to handle the 2045 flows and adjoins Site 2b which if required could be added. It is close to the CRD trunk sewer and is in a commercial district.	Preferred
2b	Colwood VMP at Meaford Avenue	0.50	This site is in Colwood and is not large enough on its own to handle the 2045 flows from Langford.	Not Preferred
3	Colwood Gravel Storage	2.64	The South Colwood node is significantly further away from the CRD trunk, which increases the infrastructure required, compared to the North Colwood node. The South Colwood sites are also further away from the reuse opportunities (boulevard irrigation, golf course irrigation and aquifer recharge) that have been identified compared to the North Colwood sites.	Not Preferred
4	Colwood Gravel Pit	9.72	The South Colwood node is significantly further away from the CRD trunk, which increases the infrastructure required, compared to the North Colwood node. The South Colwood sites are also further away from the reuse opportunities (boulevard irrigation, golf course irrigation and aquifer recharge) that have been identified compared to the North Colwood sites.	Not Preferred
5	Colwood City Hall	3.06	The South Colwood node is significantly further away from the CRD trunk, which increases the infrastructure required, compared to the North Colwood node. The South Colwood sites are also further away from the reuse opportunities (boulevard irrigation, golf course irrigation and aquifer recharge) that have been identified compared to the North Colwood sites.	Not Preferred
6	Colwood Pattison Pit	4.97	The South Colwood node is significantly further away from the CRD trunk, which increases the infrastructure required, compared to the North Colwood node. The South Colwood sites are also further away from the reuse opportunities (boulevard irrigation, golf course irrigation and aquifer recharge) that have been identified compared to the North Colwood sites.	Not Preferred

Appendix F – Updated Site Prioritization

Site Number	Site Name	Estimated Usable Area (ha)	Comments	Conclusion
7	Colwood Lower Allandale Pit	1.24	The South Colwood node is significantly further away from the CRD trunk, which increases the infrastructure required, compared to the North Colwood node. The South Colwood sites are also further away from the reuse opportunities (boulevard irrigation, golf course irrigation and aquifer recharge) that have been identified compared to the North Colwood sites.	Not Preferred
8	Colwood Upper Allandale Pit	1.66	The South Colwood node is significantly further away from the CRD trunk, which increases the infrastructure required, compared to the North Colwood node. The South Colwood sites are also further away from the reuse opportunities (boulevard irrigation, golf course irrigation and aquifer recharge) that have been identified compared to the North Colwood sites.	Not Preferred
9	Colwood City Centre	1.02	This is a private site that is encumbered with some extensive building foundations already built. It is also further from the north boundary of Colwood than other sites in the North Colwood node.	Not Preferred
10	Colwood VMP City Centre Adjacent	0.66	This is a private site that is encumbered with a lot of commercial businesses.	Not Preferred
11	Colwood Park and Ride	0.74	This site is owned by the City of Colwood and is large enough to handle the 2045 flows assuming tertiary liquid treatment and no solids treatment is required on the site.	Preferred
12	Colwood Island highway	1.70	This a relatively large private site, but compared to Site 11 it is not preferred because of risks associated with private landowners.	Not Preferred
13	Colwood Wale Road	0.41	This a private site that is too small to handle the 2045 flows.	Not Preferred
14	Colwood West Shore Parks :& Rec.	6.62	This park site is owned/managed by five municipalities. It is ideal from a land area perspective, but may be complicated to secure. It would be possible to use land on the site that is not currently used for recreational purposes.	Preferred

Appendix F – Updated Site Prioritization

Site Number	Site Name	Estimated Usable Area (ha)	Comments	Conclusion
15	Esquimalt Nation	3.72	This land is owned by the Esquimalt First Nation and is the second largest site available. It is also the closest, large site to the Macaulay Outfall. It is large enough to handle the liquid treatment to 2045 but not the liquid and solids to 2045. The site is on Admirals Road right beside the CRD trunk.	Preferred
16	View Royal Burnside & Watkiss	1.13	This site is owned by the Province and has a high voltage BC Hydro line bisecting the property. Since the site would only handle View Royal flows the area is okay for 2045 flows.	Preferred
17	Esquimalt Bullen Park	2.18	This park site requires restoration of the recreational aspects, which means much of the plant would have to be underground. The area is inadequate to treat 2045 flows. The site is in a residential neighbourhood as well.	Not Preferred
18	Esquimalt Town Centre	0.77	This site is too small to handle 2045 flows.	Not Preferred
19	Esquimalt Works Yard	0.69	This site is too small to handle 2045 flows.	Not Preferred
20	Esquimalt Lampson Field	1.38	This site is too small to handle 2045 flows.	Not Preferred
21	Colwood Golf Club	0.60	This site is too small to handle 2045 flows.	Not Preferred