APPENDIX B

Capital Regional District

Core Area Liquid Waste Management Plan

Phase 2: Wastewater Treatment System Feasibility and Costing Analysis

Technical Memorandum #4 – Analysis Summary

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Appendices

EXECUTIVE SUMMARY

Phase 2 centers on technical and financial analysis regarding wastewater treatment and resource recovery for the Core Area. Regional services require clear definition of levels of service. Technical findings on their own do not justify a specific direction, rather, it is the synthesis of technical, public and political needs and aspirations that determine the direction for level of services. Technical Memorandum #4 summarizes the technical and financial analysis to support Committee decision-making. Phase 2 policy areas include:

Water Reuse: Water innovation and stewardship drives the concept for reuse, however there are technical and financial challenges to overcome. Phase 2 findings suggest that any reuse systems could be introduced incrementally when customers and water rates validate their installation. The two plant option (Colwood and Rock Bay) enables a notable increase in water reuse from a single central plant.

Solids Recovery[1]: The decision to integrate municipal and wastewater solids in the near-term shapes the location of solids recovery. Phase 2 findings suggests that Hartland Landfill offers distinct advantages if there is direction by the Committee to process both wastewater and municipal solids on a regional scale. Alternatively, to pursue solids recovery at Rock Bay would focus capacity on primarily wastewater solids.

Level of Treatment: Secondary treatment fulfills regulatory requirements yet tertiary treatment offers enhanced water quality but with increased capital and operating costs. Rock Bay Secondary provides up to 10% tertiary treatment: selecting 100% tertiary treatment is a local decision regarding preferred level of service based on public and political input. The capital costs to achieve 100% tertiary treatment is similar to a two-plant, sub-regional option.

Conveyance and Site Design: The cost and routing of conveyance infrastructure requires appropriate resources and collaboration with municipal partners to mitigate against neighborhood interruption. Direction by the Committee to prioritize routing optimization and site design reflects technical and public findings through the planning process.

Number of Facilities and Location: Among the seven option sets, a central plant (Rock Bay) or two plant option set lowers complexity and enables economies of scale to lower costs e.g. two plants at Esquimalt Nation and Rock Bay is roughly equivalent in capital cost to *1 Plant Rock Bay Tertiary*. There are technical and financial disadvantages to increasing the number of plants. However, adding more facilities could be done incrementally to service growth or if reuse/recovery systems prove their feasibility beyond the 2030 scenario, in locations such as Colwood, East Saanich and Esquimalt.

These technical policy areas can be combined with public input and preferences for the Committee's benefit of selecting levels of service, siting and infrastructure for establishing the plan forward.

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[1] The Request for Statements of Interest (RFSI) process will yield market-specific economic and feasibility information to decide on an effective approach to wastewater solids recovery.

1.0 PHASE 2 APPROACH AND METHODOLOGY

1.1 Phase 2 Objectives

The Project Charter details the aspirations and commitments set out by the Core Area Liquid Waste Management Committee (the Committee). Current treatment standards in the Core Area include screening prior to outfall which triggers new works to comply with federal and provincial regulations. Phase 2 provides the analysis and results to illustrate options for new levels of service to meet and exceed the looming regulatory changes. Each technical memorandum delivered to the Committee outlines the ingredients for service delivery, engineering, treatment, recovery and financial considerations, including:

- Capital and operational requirements for secondary, tertiary and/or sidestream tertiary treatment;
- Water reuse including locations, potential customers, pricing considerations and capital/operating requirements;
- Heat recovery economics and the opportunity to build systems when energy pricing supports it;
- Solids recovery including the location, options for wastewater byproducts only and the opportunity to integrate wastewater services with solid waste services; and
- Collection and conveyance infrastructure including outfalls, pump stations, trunk mains and the opportunity to manage flows on a core area-wide basis, or, sub-regionally.

The information summarized in this memo and presented throughout Phase 2 provides the technical basis for the Committee to assess trade-offs and establish the next level of service. Combining the technical data with public input meets legislative requirements but goes further to enable this Committee to deliver on its commitments to ratepayers to decide on preferred concepts for wastewater treatment and resource recovery.

Representative Design

Representative design includes provisionally selecting technologies and processes to illustrate how they perform against technical criteria. While analysis and reporting will refer to provisional solutions including costs estimates that are based on representative technologies, the process outcomes are not locked-in, which allows for further innovations by the market at the time of procurement. Representative design helps the process to allow for fair comparisons among the 7 option sets and provides a placeholder for innovation until the market responds to the opportunity in delivering a regional treatment solution in the Capital Region.

1.2 Phase 2 Methodology

Life-cycle costing analysis provides the Committee with financial information on seven wastewater option sets for treatment and resource recovery. Phase 2 life-cycle costing analysis should be integrated with the results of recent public consultation so as to buttress the technical findings with community aspirations: a thoughtful blend of public, political and technical outcomes from Phase 2 supports the Committee in making a decision on a preferred system for wastewater treatment.

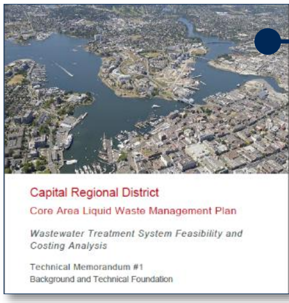
The Phase 2 methodology includes technical criteria and analysis that reflects the goals of Phase 2 as outlined in the Project Charter. These criteria frame the technical choices and how to characterize the performance of the seven option sets. In other words, this approach builds in public preferences to date to design the option sets, but later, this approach also ensures that performance results are framed by how well they deliver on local service expectations. Public education, dialogue and reflection on the technical results of Phase 2 helps to refine the regional aspirations and further informs the Committee on selecting a preferred direction. Later, technical criteria can be combined with the results of public consultation so that implementation of the project, including procurement processes and private sector proposals, that can respond to the concrete objectives and requirements that emerge from this process.

Levels of service, costs and environmental performance frame the comparison among the seven option sets. Ratepayer feedback on proposed levels of service are essential to assessing criteria including thresholds for affordability and environmental expectations. Each option outlines its capital and operating costs as well as revenue estimates alongside its level of service which allows stakeholders to weigh the trade-offs among the alternatives. Because the technical criteria go beyond financial, option set characterizations are broad and allow for a deeper appreciation of the costs and benefits of services, such as water reuse, heat recovery and distributed systems. While no single alternative can fully address the range of criteria, it is the presentation of the alternatives and the ensuing debate that will help to clarify the technical-social feedback that supports Committee direction.

Cost Estimating

Cost estimates for the seven option sets reflect the terms of reference set by the Committee and adhere to senior government guidelines for public works and government services. Each option set includes a detailed list of works and their capacities including pipes, pump stations, treatment plants, solids recovery and other infrastructure to build the proposed system. Industry-relevant unit rates apply to the list of works to create construction costs. Various factors such as overhead and profit, engineering fees, project management, interim financing and escalation overlay the construction costs to develop program-budget costs. The resulting costs are well suited to public consultation and appropriate for decision making to narrow down to a preferred concept.

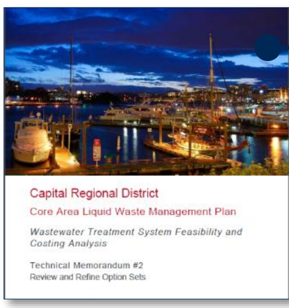
Overall, the four technical memos provide the detailed account of the Phase 2 technical methodology including analysis and results.



Technical Memorandum #1

Background and Technical Foundation

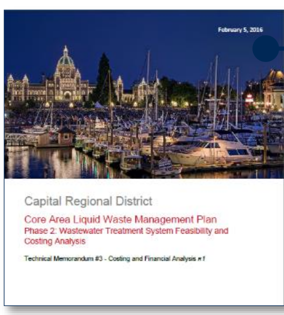
Details the overall Phase 2 methodology, summarizes design flows, explains the role of representative design, describes how option sets will be developed and itemizes cost estimating factors (Appendix C).



Technical Memorandum #2

Review and Refine Option Sets

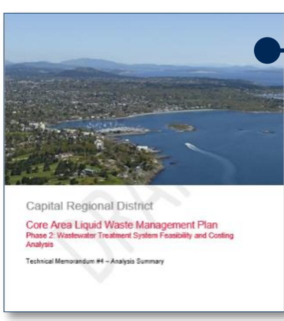
Details the representative technologies for costing and effluent performance, outlines the solids treatment and recovery options, itemizes the infrastructure and system components (e.g. lineal meters of pipe, cubic meters of capacity) and confirms the level of service for treatment and infrastructure across the option sets (Appendix B).



Technical Memorandum #3

Costing and Financial Analysis

Details the capital, operating and life-cycle costing results, summarizes the overall technical characterization of each option set, identifies the financial feasibility of resource recovery and lays out policy considerations for public and political direction (Appendix A).



Technical Memorandum #4

Analysis Summary

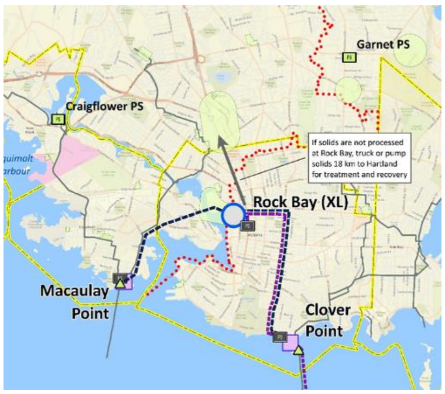
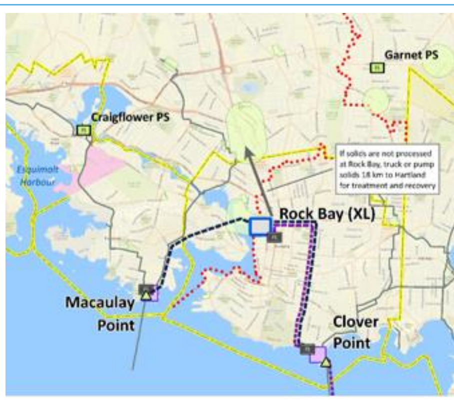
The content of Technical Memorandum #4 supports future engagement with senior government (e.g. funders, regulators) and Committee implementation activities. Results for option set costs, solids treatment, heat and water recovery and criteria performance form most of Technical Memorandum #4. Decision-making considerations stem primarily from the technical findings to help frame key policy choices for the Committee as they decide on a preferred concept for funding and ultimately a formal LWMP amendment. Life-cycle costing and overall option set performance frames the choices for the Committee in setting the level of service.

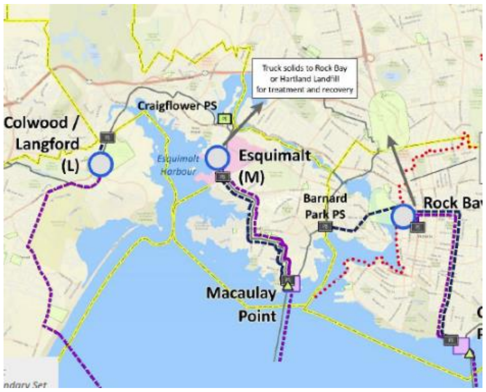
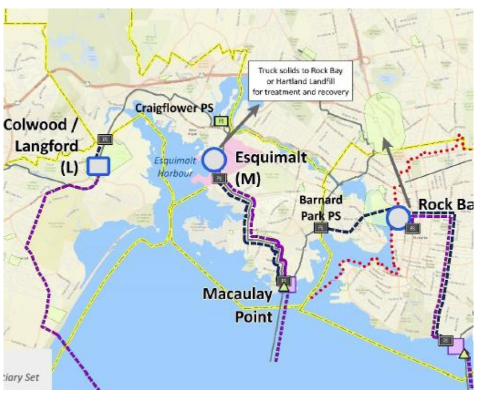
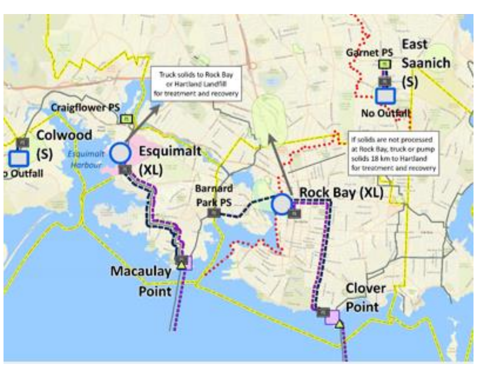
2.0 OPTION SETS SUMMARY RESULTS

2.1 Summary Table of Key Results

Table 2-1 below provides an executive summary of the seven option sets including their description and summary performance. The location, level of treatment and cost implications frame the key levels of service considerations for collection and liquid treatment infrastructure.

Table 2-1: Option Set Summary

<table>
<tr><th>Area</th><th>Description</th><th colspan="2">Performance</th></tr>
<tr><td rowspan="3">
</td><td rowspan="3">Rock Bay Central Secondary
The 1 Plant secondary treatment (1a) option set centralizes all flows at Rock Bay, including up to 10MLD for local reuse. This option set addresses the need to meet pending regulations and provides for the base level of service.</td><td rowspan="2">Capital 2030
$1,031M</td><td>2030 Operating
$21.8M</td></tr>
<tr><td>Est. Resource Income up to
$0.9M</td></tr>
<tr><td>Rank: Low Operating Cost
1st</td><td>Rank: Low Carbon & Energy Footprint
1st</td></tr>
<tr><td rowspan="3">
</td><td rowspan="3">Rock Bay Central – Tertiary
The 1 Plant full tertiary (all flows) treatment (1b) option set centralizes all flows at Rock Bay, including up to 10MLD for local reuse. This option set represents a clear sentiment towards water stewardship by raising levels of service for treated effluent quality.</td><td rowspan="2">Capital 2030
$1,131M</td><td>2030 Operating
$26.4M</td></tr>
<tr><td>Est. Resource Income up to
$0.9M</td></tr>
<tr><td>Rank: Low Operating Cost
6th</td><td>Rank: Low Carbon & Energy Footprint
3rd</td></tr>
<tr><td rowspan="3">
</td><td rowspan="3">2 Plant: Rock Bay + Colwood
The 2 Plant option set treats over 80% of flows to secondary levels, on top of up to 20% tertiary quality effluent. This option set represents a notable increase in water reuse from the 1-plant option with minimal extra conveyance infrastructure.</td><td rowspan="2">Capital 2030
$1,088M</td><td>2030 Operating
$22.8M</td></tr>
<tr><td>Est. Resource Income up to
$2.4M</td></tr>
<tr><td>Rank: Low Operating Cost
2nd</td><td>Rank: Low Carbon & Energy Footprint
2nd</td></tr>
</table>

<table>
<tr><th>Area</th><th>Description</th><th colspan="2">Performance</th></tr>
<tr><td rowspan="2">
</td><td rowspan="2">3 Plant Secondary: Colwood/Langford, Esquimalt Nation and Rock Bay
The 3 Plant option set treats over 80% of flows to secondary levels, on top of up to 20% tertiary quality effluent from sidestream re-use facilities at Esquimalt and Rock Bay. The secondary plant at Colwood/Langford allows for sub-regional flow management, including locating capacity for future growth in the Westshore.</td><td>Capital 2030
$1,125M</td><td>2030 Operating
$23.0M
Est. Resource Income up to
$1.6M</td></tr>
<tr><td>Rank: Low Operating Cost
3rd</td><td>Rank: Low Carbon & Energy Footprint
4th</td></tr>
<tr><td rowspan="2">
</td><td rowspan="2">3 Plant Tertiary*: Colwood/Langford (*tertiary), Esquimalt Nation and Rock Bay
The 3 Plant Tertiary option set treats 70% of flows to secondary levels, on top of up to 30% tertiary quality effluent from the Colwood/Langford plant on top of sidestream re-use facilities at Esquimalt and Rock Bay. This option increases water reuse to three systems and raises effluent quality to levels similar to the 4 plant option at a lower cost.</td><td>Capital 2030
$1,178M</td><td>2030 Operating
$24.0M
Est. Resource Income up to
$2.8M</td></tr>
<tr><td>Rank: Low Operating Cost
4th</td><td>Rank: Low Carbon & Energy Footprint
6th</td></tr>
<tr><td rowspan="2">
</td><td rowspan="2">4 Plant: Rock Bay, Colwood, East Saanich and Esquimalt Nation
The 4 Plant option set is a sub-regional system treating over 75% of flows to secondary levels, on top of up to 25% tertiary quality effluent. This option set represents the middle ground for distributed facilities and includes water reuse systems in four major growth centers.</td><td>Capital 2030
$1,195M</td><td>2030 Operating
$25.3M
Est. Resource Income up to
$3.8M</td></tr>
<tr><td>Rank: Low Operating Cost
5th</td><td>Rank: Low Carbon & Energy Footprint
5th</td></tr>
</table>

<table>
<tr><th>Area</th><th>Description</th><th colspan="2">Performance</th></tr>
<tr><td rowspan="3">
</td>
<td rowspan="3">7 Plant: Rock Bay, Colwood, East Saanich, Esquimalt Township, View Royal, Langford and Core Saanich
The 7 Plant option set is a sub-regional system treating up to 45% of flows to tertiary quality, including tertiary treatment for all flows on the Westside. This option set represents a highly distributed system which maximizes the potential for water reuse and situates facilities in 7 growth areas.</td>
<td rowspan="2">Capital 2030
$1,348M</td><td>2030 Operating
$26.6M</td></tr>
<tr><td>Est. Resource Income up to
$4M</td></tr>
<tr><td>Rank: Low Operating Cost
7th</td><td>Rank: Low Carbon & Energy Footprint
7th</td></tr>
</table>

2.2 Resource Recovery Feasibility Analysis

Recovery of resources available in both the liquids and solids is highly dependent on the market conditions, energy prices, environmental credits and the overall cost for the projects. Many resources can be considered and market responses based on supply or demand, and use or disposal, and price or cost will shape the preferred concept in the core area.

Solids Management and the Advantage of a RFSI

The Project Charter indicates that any option set must incorporate sustainable practices into the design and consideration of the solids management alternatives. Anaerobic digestion and gasification provide two energy positive processes that directly align with the terms of reference and the goals and commitments of Phase 2.

» **Anaerobic Digestion** is a process that maintains the wastewater solids at near body temperatures (35-39 degrees C) without the presence of air. Under these mesophilic[2] conditions the bacteria consume themselves and produce an energy-rich byproduct (methane).

Liquid Resources

- *Hydraulic/Nutrients*
- *Thermal*
- *Mechanical*

Solids Resources

- *Nutrients*
- *Energy*
- *Bio plastics*
- *Organic Soil Amendment*
- *Biomethane*
- *Biofuels*
- *Carbon Dioxide*
- *Electricity*

[2] Thermophillic digestion is an alternative to mesophilic which can reduce the time required for digestion but also requires greater heat/energy needs.

- Anaerobic digestion can reduce the organic content of the solids by 35-50% and the overall mass of the solids by 30%.
- Anaerobic digestion is the industry standard for stabilization and energy recovery in the wastewater industry.
- Anaerobic digestion typically produces 1,377 kg of wet cake at 20% dry solids per ML of treated wastewater.
- Methane gas from the digestion process would be cleaned of hydrogen sulfide and siloxanes and diverted to the c*ombined heat and power* units for the generation of power and heat. The heat generated in the engines will be used to provide the necessary heat for the digestion process and the electricity used to offset the electrical use of the mechanical equipment at the plant.

Hartland versus Rock Bay

Solids treatment and resource recovery is an important servicing decision which relates to technology, economics, environmental performance and location. Responses from the private sector will further address three of the four factors, yet location remains an important decision by the Committee. Hartland Landfill and Rock Bay offer different advantages and challenges. Neighborhood impacts, cost of land, costs of solids conveyance, integration of other municipal wastes and the destination of final residuals frames the opportunity with each site. Hartland Landfill provides distinct technical advantages including integration with other municipal waste, synergies with existing cogeneration facilities and greater flexibility in preparing (e.g. storing) residuals for market reuse. Alternatively, Rock Bay sites reduce infrastructure needs. Responses from the RFSI become more reliable with a single site.

» **Gasification** is a thermal/chemical process that converts the organic carbon in the wastewater solids into a synthetic gas that offers energy recovery potential but also may be processed into higher value items like plastics or as feedstock for biodiesel production. As this process is thermally based, it is critical that the energy content of the feed stocks be sufficient to maintain the high temperatures and derive energy out of the process.

- Gasification has been used in the municipal solid waste market as the energy content of these materials is typically sufficient for an efficient and energy positive operation.
- Gasification proponents claim to process 70% to 90% of the carbon content of the liquid waste solids feed; leaving mostly inorganic ash.
- Gasification will typically produce 14-60 kg of ash or biochar per ML of waste treated.
- Gasification generates syngas which can fuel a steam-boiler-turbine to generate power. The addition of municipal solid waste should enhance the thermal-energy process to yield significant amounts of excess thermal energy.

Key results of the capital, operating and life cycle costing analysis for solids recovery include:

- Capital costs for anaerobic digestion and gasification are deemed comparable, at $258M and $233M, respectively.
- Net present value results between anaerobic digestion and gasification can be considered roughly equal at this conceptual level (the capital cost uncertainty for gasification prevents a clear conclusion on net present value); statements of interest from the wastewater solids market will determine whether better net present value scenarios exist.
- Operational costs for gasification may be less than anaerobic digestion by a notable margin; this is primarily related to the mass of solids still present in the digested sludge and the potential cost of its disposal/reuse; market innovation on the reuse of biochar and biosolids will have a significant effect on the operating costs for either technology (which further justifies the value of market engagement).
- Operational costs for gasification decrease further as other municipal solid waste materials are added (relative to anaerobic digestion) because more energy offsets emerge.

Two financially comparable solids-energy recovery options positions the CRD to canvass the private sector to determine the most cost-effective and environmentally-beneficial alternative.

RFSI Considerations

A request for statements of interest (RFSI) details the aspirational and obligatory (e.g. risk management, financial assurance) objectives of the CRD in solids recovery, and also serves to identify and assess all of the potential market opportunities to improve upon the alternatives identified in Phase 2. The RFSI provides the CRD the option of evaluating the best technologies in a single, formal process and further informs the manufacturers on the goals of the CRD for the processing and disposal of the solids generated through the process.

The RFSI process will also provide opportunity for innovation by encouraging practical, resourceful and complete solutions to recover biosolids including their organics and energy. The RFSI should include the definition of the two *bookend*-type options (anaerobic digestion or gasification) as viable options for the CRD to implement in a way that challenges the market to produce options that are more innovative.

By being goal driven, market solutions will adhere to the progress made during Phase 2 including direction by the Committee and aspirations of the public. The RFSI can identify goals like:

1. Proposed process must recover and export energy
2. Proposed process should integrate municipal solid waste and wastewater solids
3. Proposed Process must recover and export ammonia

4. Proposed process must minimize carbon emissions
5. Proposed process must not rely on land application or landfilling of solids processed

The comprehensive list of requirements would be detailed to suit political and technical needs, for alignment with senior government funding opportunities (committed or not) and reflect key input received by the public through ongoing public consultation. The RFSI package should include extensive information on the resources available and the types of responses to be submitted.

Heat Recovery

Charter goals and commitments related to heat recovery comes from public interest in the economic and environmental feasibility of beneficial heating systems from wastewater throughout the Core Area. Analysis for Phase 2 covers planning projections, supply and demand, heating economics, service infrastructure, costs and income possibilities.

Heat recovery typically occurs via district heating systems (DHS) in select locations which are highly suited for heat distribution. Three primary factors influence the efficient distribution of excess heat energy from a wastewater facility: supply, demand and infrastructure requirements. All option sets provide treatment facilities near growth centers. Typically, the most feasible DHS scenario arises where infrastructure costs are lowest and amount of demand is greatest. Key economic factors that drive the financial viability of heat recovery include value of the heat supplied (e.g. $/GJ) relative to the cost of infrastructure and operations.

Cost-Income Analysis

Current record lows in natural gas prices combined with increasing electricity prices is narrowing the economic advantage that heat pump technology offers. For example, one unit of natural gas heat currently has a value of $14 per GJ, while a unit of heat pump heat at current electricity prices has a value of $11.67 per GJ. When infrastructure and utility operations costs are included, the price differential is largely eliminated which means district heating systems struggle to yield a positive return. Capital and operating costs estimates developed for Phase 2 identify 0.5:1 income to cost ratio. Overall, current energy prices coupled with the cost of DHS infrastructures results in insufficient revenues that may cover operating investments but do not payback capital investments in a reasonable time period.

Ingredients for Successful Heat Recovery

Heat recovery from wastewater has serious potential in broader district heating systems when the ingredients in Table 2-2 are applied:

Table 2-2: Ingredients for Successful Heat Recovery

INGREDIENT	APPLICATION
Secure partnerships with reliable building owners who are ready to invest in heating system infrastructure	*New development; preference to single-owner buildings; public agencies*
Low-infrastructure district heating systems	*New buildings situated 'on top' of effluent pipes or adjacent treatment plants*
Natural gas prices significantly exceed electricity pricing	*Future conditions may present this opportunity*
Lens on cost-effective heat recovery utilities	*Business cases based on reinvesting incomes into the utility; unlikely to offset other wastewater costs*
Public support inherent in triple-bottom line business case	*Seek out public input on the concept noting that implementation likely to occur when these ingredients for success can be met (likely in the future)*

Heat recovery from treated effluent is an attractive energy off-set strategy especially when economic conditions justify the business case for any system. Heat recovery systems in the Core Area should remain an ongoing dialogue among public, private and governmental stakeholders so that when conditions align, the CRD can partner with municipalities and developers to implement cost-effective options.

Water Recovery

When treated to a high enough standard, treated effluent can be reused instead of potable water. Water recovery target markets should deliver on the following key themes:

- Demonstrate reliable long-term demands and incomes
- Support community amenities such as stream and aquifer augmentation
- Reduce the scope of infrastructure needs
- Pursue future partnerships with industry
- Service large tracts of irrigable land such as parks and green spaces
- Demonstrate synergy with conventional public utility services
- Service growth centers where new developments can be encouraged to include additional plumbing systems for toilet flushing or irrigation

A servicing approach that meets these themes typically presents the lowest capital cost for system set up, provides long-term demands, supports community amenities such as parks and growth and generally conforms to public utility service delivery. Combined, land application and regional growth centers provide for lower-barrier locations for reuse.

Summary of Water Reuse across the Core Area

Treated effluent systems require their own, separate infrastructure for distribution. Each facility would include a pumping station which raises system pressures to cover the range of elevations and flows and also includes pipes based on conceptual routes. The capacity of each water reuse system is based on the 2030 flows with consideration to long-term flow increases. Life-cycle costing includes capital allowances for reuse systems including distribution pipes and pump facilities. Pricing for reclaimed water is proposed at 80% of potable water retail rates for toilet substitution and 80% of wholesale CRD potable rate for land application. Reuse by aquifer recharge (if pursued) will not result in revenue.

Water Reuse Feasibility Summary

Results of the cost-revenue and feasibility analysis for water reuse include five key outcomes:

- If pursued, revenues for water reuse are set to be phased-in as customers confirm partnerships with CRD or the municipality for service, gradually over a 20-year period. The feasibility of securing new customers should be explored further so that supply matches demand and there is long-term pricing security.
- Water reuse provides for innovative uses of treated effluent however it is unlikely to present a positive business case until (if) potable supplies become unreliable. Revenues from water re-use will be challenged to cover both the operating and capital financing costs of their delivery systems, and will likely create an overall operating deficit.

Flows and Capacities

Flow quality and quantity are fundamental ingredients to designing and costing wastewater treatment systems because they dictate the size of pipes, pumps and treatment systems. Municipalities and the CRD regularly explore and clarify dry weather (e.g. routine, non-rain events) and wet weather flows (e.g. irregular, weather dependent flow). The 2030 design-flow projection of 108MLD for dry-weather periods has municipal and Committee support, which provides a strong foundation to technical analysis. Regulations stipulate the redundancy requirements and expectations for treatment between 0x to 2x ADWF and 2x to 4x ADWF, and beyond. Going forward, the incentive to reduce flows, mitigate I/I, conserve potable water use and regulate the source quality of wastewater can help to defer treatment plant capacity upgrades.

- Further study is needed to discern which revenues are actual new incomes that do not result in a loss in income to the potable water utility. Generally, however, installing two sets of pipes providing a similar level of service in the same area can lead to some level of redundancy and added cost to be borne by the taxpayer.
- While the seven plant option set would provide a higher level of service and boost enhanced tertiary water quality, it may not provide greater reuse opportunities beyond the four plant option for a long time: this is because supply would likely exceed demand.
- Pursuing full tertiary treatment for all flows would be driven partly for water reuse but largely to achieve enhanced water quality that is ultimately returned to the environment.

3.0 CONSIDERATIONS FOR DIRECTION

3.1 Overall Summary

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of service based on public and political input. The capital costs to achieve 100% tertiary treatment is similar to a two-plant, sub-regional option.

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