DISCUSSION PAPER NO. 3

Capital Regional District

Core Area and West Shore Sewage Treatment Technology Assessment

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1 Objective

The wastewater management strategy that will ultimately be developed and implemented by the CRD will incorporate a variety of wastewater treatment and resource recovery technologies. The objective of this discussion paper is to identify available technologies and determine which of the technologies best reflect “representative” technologies that can be used to develop specific wastewater management options.

The review and selection process consists of three steps. The first is to review and pass or fail the technologies that may be applicable for liquid stream treatment, wet weather overflow treatment, and biosolids management. The second is to define and weight the list of the criteria that will be used to assess the applicable technologies. The third is to score the short-listed technologies for each criterion, and rank each technology as ranging from ”very high” to “very low” using the weighted criteria in a multi-criteria analysis.

It is important to understand that this selection is done in the context of the CRD situation, in terms of opportunities and scale of the wastewater management program. In terms of treatment technologies, the application of the technology in both a centralized and decentralized context is considered. Treatment technologies are also reviewed based on the premise the ultimate disposal of effluent, if not used for reuse, will be to the marine environment.

2 Treatment and Resource Recovery Technologies

A long list of the wastewater treatment and biosolids management technologies that may be applicable to the CRD is presented in Table 3-1. The technologies are broadly divided into embryonic, innovative and established technologies, depending on their level of development and application. Resource recovery technologies are also listed for each technology development level.

Each technology is given a pass/fail ranking, based on its suitability for application in the CRD situation. Only the technologies that received a “pass” in this initial evaluation are subjected to a more detailed evaluation.

TABLE 3-1

CAPITAL REGIONAL DISTRICT
CORE AREA AND WEST SHORE SEWAGE TREATMENT
DECISION INFORMATION REPORT

TECHNOLOGY ASSESSMENT

PASS / FAIL ANALYSIS

Technology	Application	Potential Benefits	Discussion	Pass/ Fail
Embryonic				
Treatment Technologies				
Combined wastewater treatment-electricity generation via microbial fuel cells	Liquid stream treatment	Energy efficient treatment	Not proven at required scale	Fail
Granular biomass processes	Liquid stream treatment	Compact process footprint	Not proven for municipal wastewater treatment	Fail
Anaerobic nitrogen removal processes	Liquid stream treatment	Energy efficient treatment	Not proven at required scale	Fail
Resource Recovery Technologies				
Combined wastewater treatment-electricity generation via microbial fuel cells	Liquid stream treatment	Energy efficient wastewater treatment	Not proven at required scale	Fail
Wastewater fermentation	Liquid stream treatment	Hydrogen fuel production	Not proven at required scale	Fail
Biomass bio-polymer extraction	Biosolids management	Biodegradable plastics production	Not proven at required scale	Fail
Oil-from-Sludge	Biosolids management	Fuel generation	Not proven at required scale	Fail
Innovative				
Treatment Technologies				
Advanced primary/secondary effluent blending	Liquid stream treatment	Reduced process size	Proven at required scale	Pass
Advanced secondary processes in series	Liquid stream treatment	Compact footprint	Proven at required scale	Pass
Membrane bioreactor followed by wetlands	Liquid stream treatment	No surface or ocean discharge	High capital cost; suitable site must be available	Pass
Bioreactor bioaugmentation using side-stream seed reactors	Liquid stream treatment - ammonia removal	Reduced process size	Ammonia removal not likely to be required	Fail
Recycle-stream anaerobic nitrogen removal processes	Liquid stream treatment - ammonia removal	Energy efficient treatment	Ammonia removal not likely to be required	Fail
Biological fluidized bed	Liquid stream treatment	Compact footprint; secondary effluent quality	Failure at recent large municipal application	Fail
Compact high-rate clarification systems	Wet weather overflows	Compact footprint	Proven at required scale	Pass
Ultra-fine screening	Wet weather overflows	Compact footprint	Proven at smaller scale; may be applicable	Pass
Waste biological sludge reduction processes	Biosolids management	Reduced biosolids; increased energy recovery	Not proven at required scale; however, may be applicable	Pass
Biosolids stabilization using landfill bioreactors	Biosolids management	Off-site stabilization	Proven at required scale	Pass
Resource Recovery Technologies				
Phosphorus crystalization and recovery	Liquid stream treatment - phosphorus removal	Slow-release fertilizer production	Not feasible if phosphorus removal is not required	Fail
Water reuse via series technology application	Water reuse	Reduced discharge through effluent re-use	Proven at required scale	Pass
Digester gas utilization in conventional fuel cells	Biosolids management	Energy recovery	Not proven at required scale	Fail
Biosolids vitrification	Biosolids management	Biosolids is melted to form glass agregates	Proven at required scale	Pass
Established				
Treatment Technologies				
Conventional activated sludge	Liquid stream treatment	Secondary effluent quality	Proven at required scale; large footprint, but can be stacked	Pass
Trickling filter/solids contact	Liquid stream treatment	Secondary effluent quality	Proven at required scale; large footprint, odour concerns	Fail
Sequencing batch reactors	Liquid stream treatment	Secondary effluent quality	Proven at required scale; large footprint, but can be stacked, mechanically complex	Fail
Rotating biological contactors	Liquid stream treatment	Large footprint; secondary effluent quality	Not economical at required scale; prone to mechanical problems	Fail
Membrane bioreactors	Liquid stream treatment	High quality effluent suitable for re-use	Proven at required scale	Pass
Biological aerated filters	Liquid stream treatment	Compact footprint; secondary effluent quality	Proven at required scale	Pass
Deep shaft activated sludge process	Liquid stream treatment	Compact footprint; secondary effluent quality	Proven at required scale	Pass
High purity oxygen activated sludge	Liquid stream treatment	Compact footprint; secondary effluent quality	Proven at required scale	Pass
Integrated fixed film/activated sludge (IFAS)	Liquid stream treatment - ammonia removal	Reduced process size	Ammonia removal not likely to be required	Fail
Powdered activated carbon activated sludge	Liquid stream treatment	Compact footprint; secondary effluent quality	Proven, but not used for municipal applications	Fail
Physical/chemical treatment	Liquid stream treatment	Compact footprint	High chemical costs, sludge production; not used for municipal applications	Fail
High-rate primary treatment	Liquid stream treatment	Compact footprint; better than primary effluent quality	Proven at required scale	Pass
Ultra-violet disinfection	Effluent disinfection	No residual chemicals in effluent; fewer safety issues	Proven at required scale with adequate upstream treatment	Pass
Mesophilic anaerobic digestion	Biosolids management	Class B biosolids produced	Proven at required scale	Pass
Thermophilic anaerobic digestion	Biosolids management	Class A biosolids produced	Proven at required scale	Pass
Enclosed biosolids composting processes	Biosolids management	Class A biosolids produced	Proven at required scale	Pass
Sludge drying/pelletization	Biosolids management	Biosolids are incinerated or used as fertilizer	Proven at required scale	Pass
Sludge drying/cement production	Biosolids management	Biosolids used as fuel source and in fly ash	Proven, but requires nearby cement plant	Pass
Thermal Oxidation / Incineration	Biosolids management	Biosolids are incinerated with possible energy recovery	Proven at required scale: emissions control required	Pass
Resource Recovery Technologies				
Membrane filtration of secondary effluent	Water reuse	Reduced discharge through effluent re-use	Proven at required scale	Pass
Biosolids land application	Biosolids management	Soil amendment; nutrient recovery	Proven at required scale if suitable land available: concerns about long-term effects	Pass
Digester gas utilization in internal combustion engines	Biosolids management	Power and heat generation	Proven at required scale	Pass

3 Assessment Criteria

The selection of the most suitable wastewater treatment, biosolids management, and resource recovery technologies for application in the CRD must consider both economic and non-economic criteria. The CRD has placed a high value on the use of sustainable practices and resource recovery. In addition, various site-specific factors must also be considered.

The assessment is based on both economic and non-economic criteria. The principal economic criterion used is the relative life cycle cost, based on the experience of the consultant team. A more detailed life cycle cost analysis will be used in the next phase to decide between the various technologies for particular applications. The non-economic assessment criteria used are divided into the following three categories: technical, operations, and environmental/aesthetic. The criteria used to assess the alternative technologies are presented below. The relative weightings (from 5 to 10, with 10 being the most important) for each criterion are shown in Table 3-2.

Economic Criteria

- *Cost Effectiveness:* On the basis of life-cycle costs, is the technology cost effective relative to other technologies?
- *Energy Requirements:* What are the energy requirements relative to other technologies?

Technical Criteria

- *Space Requirements:* How much land area is required to build the full-scale facility?
- *Process Reliability:* Has the technology been proven at the required scale? Can the technology reliably meet the effluent criteria under all expected operating conditions?
- *Flexibility:* Can the technology be adapted to meet more stringent effluent standards in the future? Can the process be readily expanded to treat higher flow and loads in the future?
- *Residuals Generation*: What is the quantity of screenings, grit and biosolids that cannot be beneficially reused and will require disposal?
- *Potential for Resource Recovery:* What is the potential to beneficially reuse the effluent and biosolids? Are heat and power generation possible?

Operating Criteria

- *Ease of Operation & Maintenance*: How much operator attention is required during normal operations? Does the technology involve a high degree of mechanical complexity with high service requirements?

- *Operator Environment & Safety*: What are the risks to O&M staff inherently associated with the technology? Will the facility be noisy or odorous for plant staff?

Aesthetic/Environmental Criteria

- *Impact on Local Environment*: Are there any odours that are inherently associated with the technology? What are the visual, noise and traffic impacts on the surrounding neighbourhood?

- *Greenhouse Gas Emissions*: Does the application of the technology result in excessive greenhouse gas emissions?

- *Chemical Demand*: Does the technology require chemicals that use up significant amounts of energy and resources in their manufacture and transport?

4 Multi-Criteria Analysis

The twenty-five applicable technologies that received a "pass" grade in the initial assessment are listed in Table 3-2. There are nine liquid treatment stream technologies, three wet weather overflow treatment technologies, one effluent disinfection technology, two water reuse technologies, and eleven biosolids management technologies.

The results of the multi-criteria analysis, using the twelve weighted assessment described above, are also presented in Table 3-2. Each technology was given a score of either -1, 0 or +1 for each of the weighed criteria. The weighted scores were then added, and the total value used to rank each technology into terms of its suitability in a CRD application. The rankings are arranged in terms of "very high" to "very low".

5 Selection of Representative Technologies

As noted, the objective of the technology assessment is to determine what technologies are most applicable to CRD situation. In other words, what technologies will the CRD likely ultimately chose? These representative technologies will then be used in the next phase of the decision making to develop overall wastewater management system options. The use of "representative" technologies in this manner will reduce the possibility of technology bias, impacting the overall system decisions.

Representative technologies for each area are discussed below. It should be noted that "representative" does not necessarily mean the highest scored technology. The selection by the consultant team uses the scoring as a guide but also reflects the judgment of the team in the combination of technologies for a particular application.

TABLE 3-2

CAPITAL REGIONAL DISTRICT
CORE AREA AND WEST SHORE SEWAGE TREATMENT
DECISION INFORMATION REPORT

PASSING TECHNOLOGY ASSESSMENT

SUITABILITY RANKING

Technology	Application	Multi-criteria Analysis												Total	Ranking
		Cost Effectiveness	Energy Requirements	Space Requirements	Process Reliability	Flexibility	Residuals Generation	Resource Recovery Potential	Ease of O & M	Operator Environment & Safety	Impact on Local Environment	Greenhouse Gas Emissions	Chemical Demand		
Weighting		10	6	9	9	7	5	8	6	7	10	8	5		
Advanced primary/secondary effluent blending	Liquid stream treatment	1	1	1	1	1	-1	-1	1	1	1	0	-1	46	**High**
Advanced secondary processes in series	Liquid stream treatment	-1	-1	0	1	1	0	0	-1	0	1	1	1	17	**Low**
Membrane bioreactor followed by wetlands	Liquid stream treatment	0	-1	0	1	1	1	1	-1	1	1	1	1	47	**High**
Membrane bioreactors	Liquid stream treatment	0	-1	1	1	1	1	1	0	1	1	1	1	62	**Very High**
Biological aerated filters	Liquid stream treatment	1	0	1	1	1	1	0	0	1	-1	1	1	50	**High**
Deep shaft activated sludge process	Liquid stream treatment	1	-1	1	-1	-1	1	0	0	1	1	1	1	32	**Medium**
High purity oxygen activated sludge	Liquid stream treatment	-1	-1	1	1	0	-1	-1	-1	-1	1	1	1	-1	**Very Low**
Conventional activated sludge	Liquid stream treatment	1	0	0	1	1	1	0	1	1	-1	1	1	47	**High**
High-rate primary treatment	Liquid stream treatment	1	1	1	1	1	-1	-1	1	1	1	1	1	64	**Very High**
Compact high-rate clarification systems	Wet weather overflow treatment	1	1	1	1	1	-1	-1	1	1	1	1	1	64	**Very High**
Ultra-fine screening	Wet weather overflow treatment	1	1	0	1	1	-1	-1	1	1	1	1	1	55	**High**
Ultra-violet disinfection	Effluent disinfection	1	-1	1	1	1	1	-1	1	1	1	1	1	62	**Very High**
Water reuse via series technology application	Water reuse	1	-1	1	1	1	1	1	-1	1	1	1	1	66	**Very High**
Membrane filtration of secondary effluent	Water reuse	0	0	1	1	1	1	1	0	1	1	1	1	68	**Very High**
Waste biological sludge reduction processes	Biosolids management	1	0	1	1	1	1	0	0	1	1	1	0	65	**Very High**
Biosolids stabilization using landfill bioreactors	Biosolids management	1	1	1	0	0	0	1	1	0	0	0	1	44	**High**
Mesophilic anaerobic digestion	Biosolids management	1	0	-1	1	1	0	0	1	1	1	0	1	45	**High**
Thermophilic anaerobic digestion	Biosolids management	1	-1	0	1	1	1	1	1	1	1	0	1	61	**Very High**
Enclosed biosolids composting processes	Biosolids management	1	0	1	1	0	1	1	-1	0	-1	1	1	38	**Medium**
Sludge drying/pelletization	Biosolids management	-1	-1	1	1	1	1	0	-1	1	0	1	1	28	**Medium**
Sludge drying/cement production	Biosolids management	-1	-1	1	1	1	1	1	-1	1	0	0	1	28	**Medium**
Thermal Oxidation / Incineration	Biosolids management	-1	0	1	1	-1	1	0	-1	0	-1	-1	1	-13	**Very Low**
Digester gas utilization in internal combustion engines	Biosolids management	1	1	1	1	1	0	1	-1	0	0	1	1	56	**High**
Biosolids land application	Biosolids management	1	0	0	1	0	1	1	0	1	0	0	1	44	**High**
Biosolids vitrification	Biosolids management	-1	-1	1	1	-1	1	1	-1	0	1	-1	-1	-1	**Very Low**

Notes:

Ranking categories are based on the multi-criteria score:

- Very High - more than 60 points
- High - 40 to 59 points
- Medium - 20 to 39 points
- Low - 0 to 19 points
- Very Low - less than 0 points

Liquid Stream Treatment

In a larger, centralized wastewater treatment plant application, the combination of advanced primary / secondary effluent blending is very attractive. Under this strategy, two times the average dry weather flow would be ultimately routed through a primary and secondary process. The wet weather flows, above this amount and up to a selected multiple, would go through an advanced primary process. Any surplus wet weather flow above this would go through an ultra-fine screening process. In this type of strategy, the biological aerated filtration (BAF) process is attractive, given its small footprint. Membrane bioreactors (MBR) could also be considered. In either case, the option to phase the secondary treatment portion of the works could be considered.

For a smaller, decentralized wastewater treatment plant, the MBR technology is the most attractive secondary treatment technology. This is particularly true in a water reuse situation, where MBR technology could be combined with ultra-violet disinfection technology. MBRs, followed by wetlands polishing and release to a surface water course, are also attractive at an inland location where surplus water, not used for reuse, needs to be returned to the environment.

Wet Weather Overflow Treatment

The wet weather flow management issue may conclude that stand-alone wet weather overflow plants are an attractive wastewater management solution. In this case, compact high-rate clarification systems, which can operate on an intermittent basis, or ultra-fine screening would be the technologies of choice.

Biosolids Management

Biosolids management is currently proposed at an off-site location. Whether biosolids management occurs off-site or at a plant with sufficient area to accommodate biosolids processing at the plant site, the most attractive technologies include waste biological sludge reduction processes, landfill bioreactors, mesophilic anaerobic digestion, thermophilic anaerobic digestion, digester biogas utilization in internal combustion engines and land application.