City of Kelowna

Strategic Review Biosolids Management

Summary Report

November 6, 2017

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Strategic Review

Biosolids Management

Summary Report – Rev. 3.0

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Executive Summary

The cities of Kelowna and City commissioned this project to evaluate options for the economically, socially and environmentally responsible long-term management of wastewater solids. Currently, the region's treated wastewater solids are mixed with wood chips and composted at the Regional Biosolids Compost Facility (RBCF) to produce a valued organic soil amendment called OgoGrow.

The RBCF has reached its design capacity for managing the solids. Further, and the amount of OgoGrow produced presently is more than the compost market demand – there is approximately one to two years of inventory stored.

This summary report presents findings from three earlier technical memoranda (TM's) and a stakeholder engagement program (included as appendices to this report). In those, several management options were investigated both as pre-treatment of the solids and as final disposal of the solids. Market conditions for the current operation and alternative operations were also considered. Available opportunities were screened and then presented to both city councils as well as selected stakeholders.

Conclusions

Digestion is necessary by 2019 to meet the project objectives for any biosolids management options. Digestion would both enable opportunities to divert solids from the RBCF (through land application) and reduce OgoGrow volume produced. Communication with regulators, stakeholders and public is essential for all the management scenarios considered.

Recommendations

There are eight recommendations made in this report for next steps and further work. The most important and urgent recommendations include developing preliminary design for digestion of Kelowna waste solids and implementing a public education program.

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1 Project Overview

1.1 Background

The City of Kelowna and the City of Vernon jointly use the Regional Biosolids Compost Facility (RBCF), which receives dewatered waste solids from the wastewater treatment facilities within the study area including the City of Kelowna, the City of Vernon, the District of Lake Country, and the Regional District of North Okanagan (RDNO).

The facility processes up to 30,000 wet tonnes of dewatered waste solids per year, which is delivered by truck to the RBCF and mixed with wood chips to create Class A compost. The compost is marketed as "OgoGrow" - a valued soil amendment in the Okanagan region. Space limitations at the active 9-hectare composting site affect both processing and storage operations, where compost inventory has been increasing and processing capacity has reached its limit.

This report summarizes the team's technical work, incorporates findings from the stakeholder engagement process provides recommendations for next steps and further investigations.

1.2 Project Approach

The City of Kelowna retained the services of Opus International Consultants (Opus), Sylvis, and Black & Veatch in July 2016 to undertake a strategic review of Kelowna and Vernon's biosolids management program, and to provide recommendations for both short term and long term options for sustainably and affordably managing their biosolids. The objective was to consider all available technology options with attention to risks from regulatory, social, and economic/market perspectives.

At the commencement of the project, representatives from the City of Kelowna, the City of Vernon, and technical experts in the fields of wastewater and biosolids management reviewed the key project objectives as well as wider perspectives such as changing regulatory landscape, recent objections by other BC communities on certain biosolids management practices, as well as historical and current technology trends. A preliminary list of evaluation criteria was developed at that meeting. Three technical memoranda (TM) and one workshop developed the work.

Following the completion of these TM's, the cities identified the need to engage key public and regulatory stakeholders to communicate the findings and receive input on the project.

A formal stakeholder engagement program was initiated in February 2017 and resulted in information sessions with local governments, regional stakeholder boards, and selected groups from the public. The results and findings from the stakeholder engagement program were summarized in an Engagement Summary Report. Informal meetings were also held with the Ministry of Environment and Westbank First Nation staff. Feedback from those stakeholder engagement meetings has been considered when preparing this report.

1.2.1 Technology Review and Screening TM's

TM-1 established the capacity and operating conditions of municipal sources of waste solids[1] as well as the RBCF. It then assessed a total of four pre-treatment options and three outlet options for their technical, financial, environmental, and geographical viability. These options are not standalone or exclusive, but each contributes to the objectives.

Workshop A "Technology Screening" followed TM-1 to review and discuss all available technologies and to screen only those most suitable technologies.

TM-2 summarized the screened technologies. Pre-treatment technologies included digestion, chemical pre-treatment, and thermal drying. Lime stabilization was eliminated as a pre-treatment option. Two outlet options were carried forward, namely the existing composting operation and land application of digested biosolids. Thermal destruction was eliminated as an outlet option. TM-2 also established and defined non-financial seven criteria for further screening the management options:

- Odour
- Environmental Quality (Air, Water, and Soil)
- Social (Public Acceptance and Perception)
- Market Risks (Supply and Demand)
- Regulatory and Bylaw Risk
- Environmental Risks
- Operations

TM-3 considered the market conditions and market pressures (markets for both the input materials and the output opportunities). It considered risks related to demand for (or public resistance to) the outlet option as well as risks related to the supply of materials for the composting operation. TM-3 Appendix A also provided a detailed review of land application opportunities, energy recovery, and the regulatory landscape.

Following the completion of the technical work, the cities initiated a stakeholder engagement program. The program was designed:

a. "To provide city councils with community and stakeholder feedback to inform their decision-making related to next steps in strategic wastewater solids management planning"; and
b. "To engage the community and stakeholders in reviewing and commenting on key planning considerations related to economic, environmental and technical considerations."

The stakeholder engagement program validated expectations related to the composting facility operation as well as land application, and resulted in a recommendation for more public education about the challenges and opportunities related to wastewater solids management.

[1] In this report, the terms "waste solids" and "solids" are used interchangeably to refer to untreated solids from wastewater facilities. Waste solids is meant to differentiate from "biosolids" which are solids which have undergone further treatment.

2 Biosolids Management Objectives

The overall management strategy must achieve the following key objectives, which are informed by the technical, economic and environmental constraints but also by social impacts and constraints echoed during the stakeholder engagement.

- **Objective 1: Increase capacity to treat wastewater solids to support growth in the Cities.**
  - » The RBCF is operating at, or near the installed compost production capacity (TM-1).
- **Objective 2: Align RBCF operations with compost market.**
  - » OgoGrow is a quality product meeting the demand of an established compost market size of approximately 35,000 m^3/year (TM-3).
  - » Compost production exceeds the market demand and inventory is growing, year over year, since 2012 (TM-3).
  - » As of 2016, there is about 1 to 2 years of OgoGrow inventory stored at the RBCF and Glenmore landfill based on historical sales.
- **Objective 3: Address long term market risks.**
  - » Operation of the RBCF relies on a single source of hog fuel to meet the carbon feedstock requirements (TM-3). Additionally, the RBCF is the sole outlet for beneficial use of the waste solids.
  - » Alternative beneficial use outlet such as land application have their own non-financial risks.
- **Objective 4: Ensure end products are safe for the public and the environment (air, soil and water).**
  - » Anticipated regulatory changes for the land application of biosolids in the Province need to be considered in future overall management strategies.
  - » Feedback received through the public engagement process placed a high importance on environmental stewardship and the need to preserve the integrity of land, air, and water.
- **Objective 5: Implement financially sustainable solutions that consider highest and most beneficial use of wastewater solids.**
  - » Appendix A of TM-3 identified the opportunities for beneficial reuse of the various wastewater solids management options.
  - » Feedback received through the public engagement process identified the need to consider the highest and most beneficial use of the cities' wastewater solids.

3 Final Management Measures

This section presents further refinements to alternatives and technologies advanced under TM-2. Information from TM-3 and public engagement allowed further screening of options, and also resulted in reconsidering digestion for the City of Vernon, which had been initially rejected.

3.1 Further Technology Screening

Options identified in TM-2 were re-visited following the completion of TM-3, with a focus on the findings from the public engagement program.

3.1.1 Digestion at Vernon

Digestion at the City of Vernon's Water Reclamation Centre (WRC) was reconsidered for three reasons. First, operations staff re-visited the original plant expansion plan and identified the possible availability of land if one redundant bioreactor were shared between trains. Secondly, the option of digesting only the fermented primary solids (FPS) requires less space than full digestion of FPS and thickened activated sludge (TWAS). Lastly, Vernon's plan for managing their high-strength industrial wastewater source[2] has matured and may result in treatment facilities at the WRC that may be complimentary to digestion or include a digestion component.

Therefore, digestion at Vernon's WRC can be considered again as part of the overall management plan. Alternatives 1 to 4 in TM-2 were modified to include possible digestion at the Vernon WRC of FPS and TWAS. Evaluation of how digestion would be added at the facility should be deferred until the City of Vernon decides on what measures[3] are taken to address the high strength industrial wastewater conditions.

3.1.2 Chemical Pre-Treatment

BCR pre-treatment of waste solids was reported to decrease the composting time, therefore potentially increase RBCF capacity. This option was eliminated as a part of the overall management plan because it will not reduce the volume of OgoGrow produced and therefore does not address the key limitation of the compost market demand identified in TM-3 and highlighted in the public engagement work.

3.1.3 Landfill Disposal

Landfill disposal following digestion was not considered a favourable option based on the evaluation criteria in TM-2, specifically environmental and operational criteria. It was also not supported by stakeholders from the engagement program. Therefore, this option was eliminated as a part of the overall management plan.

[2] An industrial operation within City of Vernon discharges an elevated BOD liquid stream to City of Vernon's collection system.
[3] City is completing a parallel study which includes collection and treatment changes. Report from that study is not available at time of writing.

3.1.4 Biosolids Growing Medium

If Class A Biosolids were produced directly at Vernon's WRC or Kelowna's Wastewater Treatment Facility (WWTF), soil blending and production of biosolids growing medium (BGM) would be possible. This option was eliminated as a part of the overall management plan for two reasons. Firstly, the creation of a new product for the landscape market would directly compete with OgoGrow, affecting pricing and consumer product identity. Secondly, using digestion to create Class A Biosolids will increase metal concentrations because of the mass destruction. Maximum concentration limits (mg/kg) for BGM are lower than for Class A Compost with respect to cadmium (1.5 versus 3 mg/kg), copper (150 versus 400 mg/kg), mercury (0.8 versus 2.0 mg/kg), and zinc (150 versus 500 mg/kg). Based on actual metal levels for cadmium, copper, mercury, molybdenum, selenium, and zinc in solids at both the Kelowna and Vernon facilities, the use of digested solids as feed stock for use as BGM would be problematic in terms of meeting the final metal concentrations.

3.1.5 Thermal Drying

Thermal drying of TWAS solids is deferred from consideration until the optimal digestion approach can be identified. While its resulting volume and mass reduction of 90% would be favourable for transport costs, the degree that reduced transport costs offset the capital expenditure depend on the location for land application. Further, digestion of FPS alone may not be favoured.

3.2 Final Management Options

Table 3-1 relists the solid production forecasts from TM-1.

Table 3-1: Summary of Average and Maximum Month Solids Production

		Without Digestion			With Digestion		
Year		2015	2035	2065	2015	2035	2065
Average Annual Production (Design Basis)							
Kelowna	dry tonnes/day	10	13	21	5	7	11
	wet tonnes/day	51	69	109	28	38	60
Vernon	dry tonnes/day	5	6	8	3	3	4
	wet tonnes/day	22	27	39	12	15	21
Lake Country	dry tonnes/day	1	1	2	0.5	1	1
	wet tonnes/day	4	6	9	2	3	5
Total	dry tonnes/day	15	20	31	8	11	17
	wet tonnes/day	78	103	157	43	56	86
	wet tonnes/year	28,466	37,455	57,236	15,700	20,600	31,480
Maximum Month Production (Based on 1.3 times average annual)							
Kelowna	dry tonnes/day	13	17	27	7	9	15
	wet tonnes/day	67	90	142	37	50	78
Vernon [a]	dry tonnes/day	6	7	10	3	4	6
	wet tonnes/day	29	36	50	16	20	28
Lake Country [a]	dry tonnes/day	1	2	2	1	1	1
	wet tonnes/day	6	8	12	3	4	6
Total	dry tonnes/day	20	26	40	11	14	22
	wet tonnes/day	101	133	204	56	73	112

Notes:
a) Digestion at Vernon is to be confirmed. Digestion at Lake Country is not feasible – but values are indicative if it were.

From the final screening herein, the only remaining pre-treatment option was digestion. Outlet options include continued composting at the RBCF and land application – the latter having up to four different potential strategies.

Digestion is a requirement for both outlet options since land application requires it and since expansion of the RBCF (i.e. the no-digestion scenario) is not supported by compost market limits. Table 3-2 summarizes the types of digestion approaches from TM-2.

Table 3-2: Management Alternatives

TM-2 Alternative	Pre-treatment	Final Disposal
1	Digestion (Class B) of all solids.	Combination of RBCF and land application.
2	Digestion (Class A) of all solids.	Combination of RBCF and land application.
3	Digestion of FPS only (Class B).	Combination of RBCF and land application.

Notes:
(a) Applied to City of Kelowna. For each alternative, digestion at Vernon can be considered, but after industrial high-strength source management is in place.
(b) Land application remains a viable option for further study with probable implementation solution by year 2028 per Table 5-1.

3.3 Metals Management Considerations

OgoGrow is produced using undigested solids and trace metal concentrations in OgoGrow are consistently below OMRR limits for Class A Compost[4]. If digestion is implemented, trace metal concentration in the digested solids is expected to increase because of the mass destruction that takes place in the digestion process. Therefore, changes in trace metal concentration in the feedstock to the composting operation were studied to assess those concentrations in the final compost product.

Historical trace metal concentrations from the City of Kelowna WWTF[5] and City of Vernon WPC[6] were reviewed. Table 3-2 shows average metal concentrations in centrifuge solids measured monthly (from 2003 to 2017 for Kelowna and 2016 to 2017 for Vernon), including an estimate of blend based on the same 70% Kelowna and 30% Vernon solids production ratio (excludes Lake County). These values are before blending with other materials at the RBCF. Existing OgoGrow metals content is also shown. Table 3-2 also shows the expected changes in trace metals concentrations if digestion were implemented (FPS and TWAS) assuming 45 percent overall mass destruction, as well as an estimate of the increased metal concentrations in OgoGrow if all solids used at the RBCF are digested.

Based on this initial analysis, none of the metal limits are expected to be an issue for land application (Class A or B biosolids). Depending on the what digestion scenario is used and whether any changes are made in the mix ratios used at the RBCF, limits for Class A compost may be an issue for selenium. Copper and molybdenum are near the limit for Class A compost but appear to be gradually decreasing. Selenium levels are higher in Vernon than in Kelowna.

Further characterization of the metals in the FPS versus the TWAS and investigation of the sources of these metals is recommended and the estimates should be updated both to account for Lake Country (no metal data obtained) and for the final digestion scenario adopted.

[4] Tables 2-2 and 3-7 of TM-1.
[5] Monthly data from January 2003 to June 2017 were included. While some metals have decreased year to year (including Cadmium, Copper, and Molybdenum), all years were included.
[6] Monthly data from January 2016 to October 2017 were included.

Table 3-2: Trace Metals Concentrations – With and Without Digestion (mg/kg)

	Existing Operation				Estimate After Digestion [b]	
Trace Metal	Kelowna Solids (Average)	Vernon Solids (Average)	Kelowna to Vernon Blended Solids	OgoGrow Current Conditions	Blended Biosolids	OgoGrow Estimated [a] New Conditions
Arsenic	1.51	1.50	1.51	4.2	2.8	4.2 – 4.7
Cadmium	0.89	0.71	0.84	1.5	1.5	1.6 – 1.8
Chromium	17.08	9.20	14.71	12.9	26.8	15.9 – 17.7
Cobalt	2.01	1.41	1.83	2.2	3.3	2.5 – 2.8
Copper	546	278	466	233	850	350 – 390
Lead	14.15	6.55	11.87	10.0	21.6	12.5 - 13.9
Mercury	0.93	0.40	0.77	0.35	1.4	0.5 - 0.6
Molybdenum	5.73	5.37	5.62	3.5	10.2	4.8 - 5.3
Nickel	11.71	7.60	10.48	7.8	19.1	10.1 - 11.2
Selenium	2.95	4.38	3.38	1.6	6.1	2.4 - 2.7
Zinc	271	285	276	333	500	381 - 423

Notes:

a) Based on current metal concentrations of centrifuge cake, estimated metal concentrations after digestion, and same mix ratio of solids to wood mix, ash, and water. If the amount of wood is changed, there would be a resulting change. Calculated mix ratio of input solids to compost mix is 0.4 by weight based on TM-1 section 2.4.1 but is plus / minus 10 percent.

b) Assuming 45% overall mass destruction

Five of the above trace metals after digestion are important for applicable regulatory limits depending on the final outlet market. Table 3-3 compares those five to various regulation limits. Land application of biosolids will not be limited, but compost quality could be depending on which regulatory limits are applied.

Table 3-3: Trace Metals Conditions after Digestion (mg/kg)

	Biosolids Land Application			Compost Markets			
Trace Metal	Blended Digested Biosolids	OMRR Limits Class A - Biosolids	OMRR Limits Class B - Biosolids	OgoGrow Estimated Conditions	OMRR Class A Compost Limits	CCME Class A Compost Limits	OMRR BGM Limits
Copper	850	-	2200	350 – 390	400	100	150
Mercury	1.4	5	5	0.5 - 0.6	2	0.8	0.8
Molybdenum	10.2	20	20	4.8 - 5.3	5	5	5
Selenium	6.1	14	14	2.4 - 2.7	2	2	2
Zinc	500	1850	1850	381 – 423	500	500	100

Notes:

a) Based on current metal concentrations of centrifuge cake, estimated metal concentrations after digestion, and ratio of input solids

Selenium appears to be a potentially limiting trace metal. Either deferring digestion of some streams, reformulation with more wood waste, or a combination would be effective at managing trace metal levels. Canadian Food Inspection Agency (CFIA) guideline T-4-93 and Canadian Council of Ministers of the Environment (CCME) have limits to maximum application rates (e.g. kilogram of metal per year) as well as cumulative metals applied. CFIA currently requires OgoGrow labelling include a maximum application rate. If digestion is implemented and the metal concentrations increase, the application rate for OgoGrow may be reduced – which is a potential marketing negative.

4 Management Alternatives

4.1 Methodology

For comparison, a baseline "status-quo" scenario was assumed, namely expansion of the current RBCF operations with no other treatment or pre-treatment changes either at the Kelowna WWTF or at the Vernon WRC. Alternatives were sized for design year 2035 conditions, but tested whether they achieved the project objectives based on average annual conditions in the future. The following assumptions were made in analysing the possible management alternatives:

a. Facility Sizing Design Criteria
   i. Design year is 2035.
   ii. Processing capacity at the existing RBCF is 16 dry tonnes per day (dt/d).
   iii. Design year undigested solids production projection is 26 dt/d.
   iv. Compost market capacity in 2035 is estimated at 35,000 m^3/yr.

b. Digestion Pre-treatment
   i. Class B digestion for Kelowna would be at a new site location within 1.6 km of the existing WWTF and the feed and return stream would be pumped to and from the existing WWTF.
   ii. Class B digestion at Vernon would be at the existing WRC.
   iii. 45% overall mass destruction
   iv. Mesophilic digestion with mean cell residence time of 15 days at maximum month.
   v. Ratio of FPS to TWAS solids is 45% to 55%.

c. Land application of Class A or Class B
   i. Potential sites for future analysis would be within 100 to 200 km of the Kelowna WWTF or the Vernon WRC for the respective biosolids source.

d. Capital costs are inclusive of 50% contingency and 25% engineering fees. All costs are in 2017 dollars.

4.1.1 Balance of Solids and Compost Production

With no pre-treatment of the solids, there is an immediate need to divert solids from the RBCF since compost production exceeds demand. With digestion, diversion can be initially deferred. Therefore, to evaluate at which year the City would need to divert pre-treated solids from the RBCF, the projected annual solids production for each pre-treatment scenario (and its related compost production) was compared to the projected market demand for the period 2017-2035.

Using a projected growth rate of 1.51%, the population for the three municipalities (Kelowna, Vernon, and Lake Country) was calculated. Using the ratio of the population at any given year to the population at year 2015, the projected solids produced was calculated and four pre-treatment scenarios were defined.

4.1.2 OgoGrow Market Demand

The annual market demand for OgoGrow was corrected to account for reducing the existing two year inventory by year 2035 in addition to using all the new OgoGrow produced – providing an "inventory corrected demand". Inventory corrected market demand in 2017 was 25,000 m^3/yr of OgoGrow growing to 35,000 m^3/yr of OgoGrow.

4.1.3 Land Application Potential

As discussed in the TM-3 Appendix A, multiple land area types were identified that could potentially be used for this purpose. Should land application be pursued as an outlet option, the availability and suitability of land would have to be assessed on a case by case basis.

Further evaluation of social impacts around quality of life and public health considerations as well as assessment of environmental sustainability, financial sustainability, and operational/technical viability for a specific application opportunity are required.

4.2 Scenario Development

A total of nine scenarios were developed. Rather than separate alternatives, they are operating scenarios made possible with digestion and are not mutually non-exclusive. Together they provide boundary conditions of all options. Alternative outlets to the RBCF will take time to develop and will have variable costs and variable benefits. Therefore, the purpose of these scenarios is to determine the minimum degree of digestion required and the amounts of diversion from the RBCF to achieve the project objectives. Table 4-1 presents three groups of digestion scenarios having different outlet combinations. Scenario groups 2, 3, and 4 assume that the capacity of the RBCF will remain the same as the current capacity.

Table 4-1: Biosolids Management Scenarios

No.	Digestion	Land Application		RBCF Feed
		General	Biomass Plantation	
1	None – "Status Quo"	None	None	All solids
2a	Kelowna FPS	No	No	All solids
2b	Kelowna FPS	All Digested Solids	No	All remaining solids
2c	Kelowna FPS	No	All Digested Solids	All remaining solids
3a	All Kelowna Solids	No	No	All Solids
3b	All Kelowna Solids	X% of Digested Solids	No	All remaining solids
3c	All Kelowna Solids	No	All Digested Solids	All remaining solids
4a	All Kelowna and Vernon Solids	No	No	All Solids
4b	All Kelowna and Vernon Solids	No	X% of Digested Solids	All remaining solids

4.2.1 Scenario 1 - Expand Composting Facility ("Status Quo")

Figure 4-1 shows the RBCF would be expanded to meet the 2035 waste solids projections at 26 dt/d. This would include the addition of approximately 10 aeration zones (5 primary and 5 secondary) and two new biofilters for odour control. This expansion is considered technically feasible as the City owns the land adjacent to the RBCF. However, this scenario is not generally supported by the nearby residents and is for comparison only. Odour management and lack of acceptance by the neighbouring citizens would make expansion of the RBCF problematic.

4.2.2 Scenario Group 2 - Digest Kelowna FPS

Figure 4-2 shows FPS would be pumped from the Kelowna WWTF to a new digester in Kelowna. Solids would be sent to one of the following outlets:

a. Kelowna TWAS, digested FPS, and the Vernon and Lake Country solids (FPS and TWAS) would be transported to the RBCF for composting.
b. Kelowna TWAS, and Vernon and Lake Country solids would be transported to the RBCF for composting, and the digested FPS from Kelowna would be either transported to the RBCF for composting or land applied. In this option, the solids diverted to land application equals the full amount of digested solids produced.
c. Kelowna TWAS and the Vernon and Lake Country solids would be composted, with the digested FPS composted or diverted for land application. For this option, the land application would be specifically for establishing a biomass plantation where the harvested woody debris would be used as carbon feed for the composting operation. In this option, the solids diverted to land application equals the full amount of digested solids produced.

4.2.3 Scenario Group 3 - Digest all Kelowna Solids

Figure 4-3 shows Kelowna solids (FPS and TWAS) would be pumped to a new digester in Kelowna. After digestion, the digested solids would be sent to one of the following outlets:

a. Digested solids from Kelowna, and the Vernon and Lake Country solids would be transported to the RBCF for composting.
b. Vernon and Lake Country solids would be transported to the RBCF for composting. Digested solids from Kelowna would either be transported to the RBCF for composting or land applied, where the amount of solids diverted to land application has been minimized such that annual OgoGrow production equals market capacity in the year 2035.
c. Vernon and Lake Country solids would be composted and the digested solids from Kelowna would be composted or diverted for land application. For this option, the land application would be specifically for establishing a biomass plantation, where the harvested woody debris would be used as carbon feed for the composting operation. In this option, the solids diverted to land application equates the full amount of digested solids.

4.2.4 Scenario Group 4 - Digest all Kelowna and Vernon Solids

Figure 4-4, shows the Kelowna FPS and TWAS would be pumped to a new digester in Kelowna. The Vernon FPS and TWAS would be digested at the WRC. Solids would be sent to one of the following outlets:

a. The digested solids from Kelowna and Vernon, and the Lake Country solids would be transported to the RBCF for composting.
b. Lake Country solids would be transported to the RBCF for composting and the digested solids from Kelowna and Vernon would be either transported to the RBCF for composting or land applied to establish a biomass plantation which would produce woody biomass used as carbon feed for the composting operation. In this option, the solids diverted to land application is the quantity necessary so that carbon produced by the woody biomass plantation equals the total carbon feedstock demand at the RBCF.

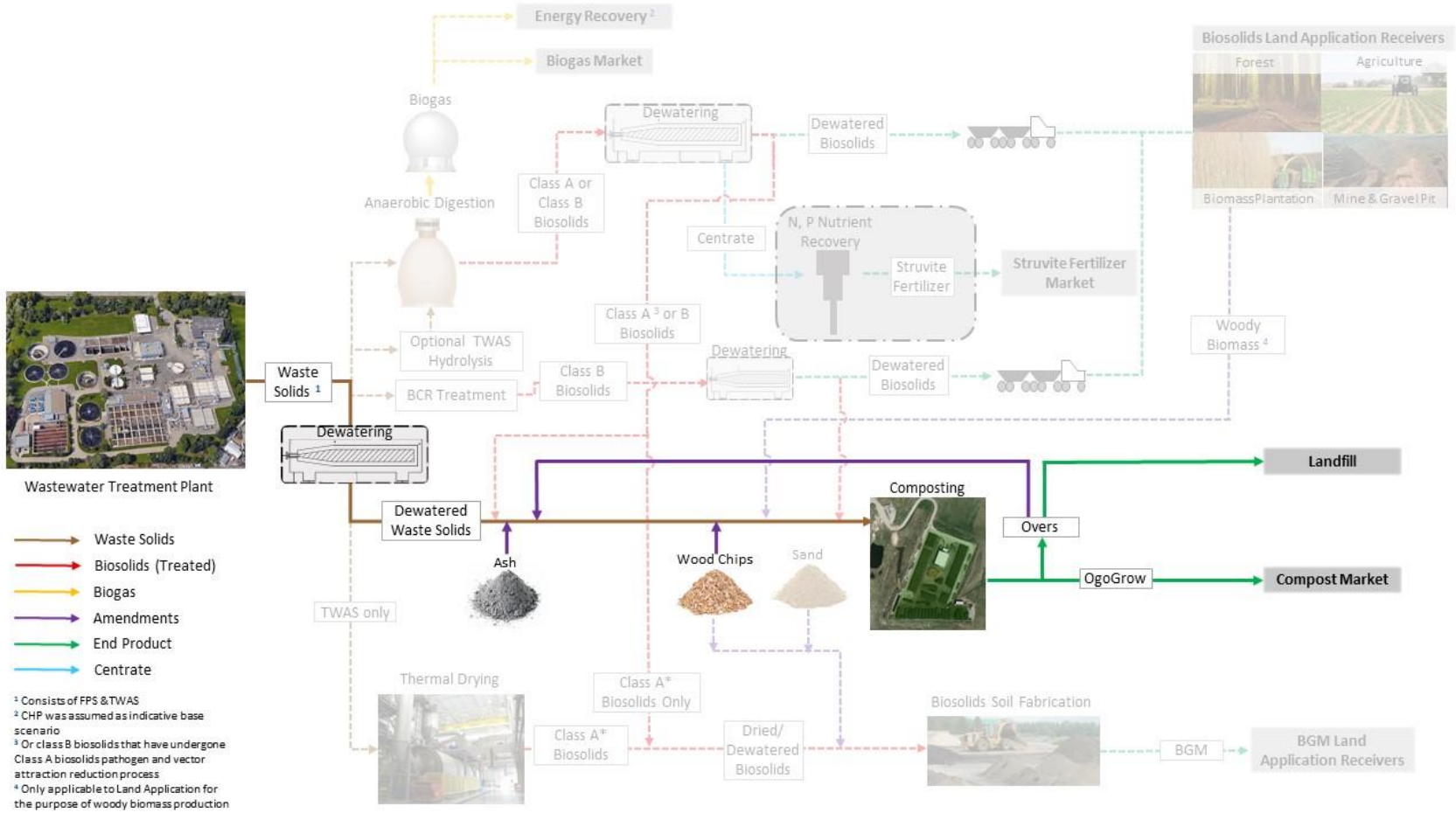

Figure 4-1: Scenario 1

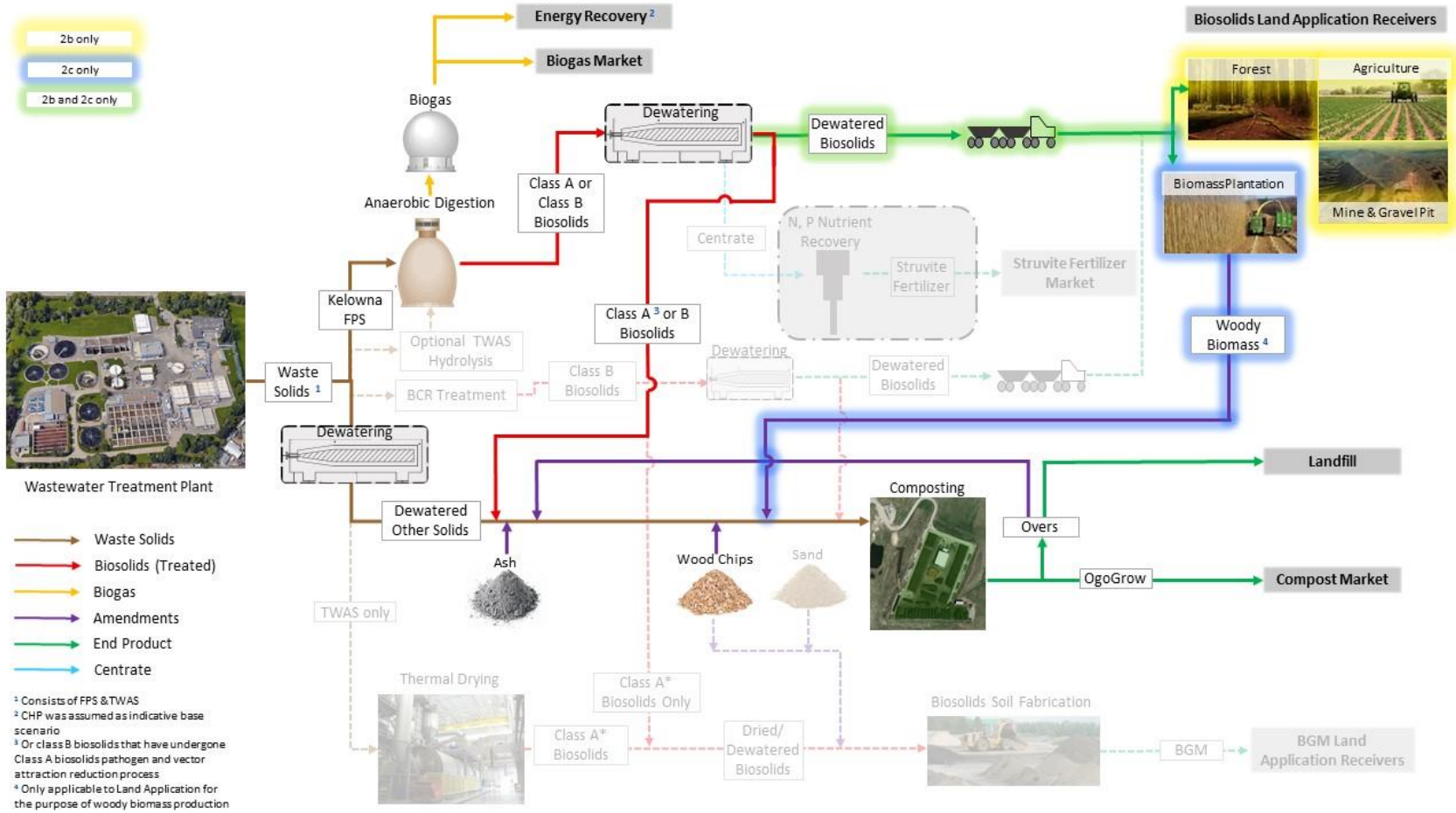

Figure 4-2: Scenario 2

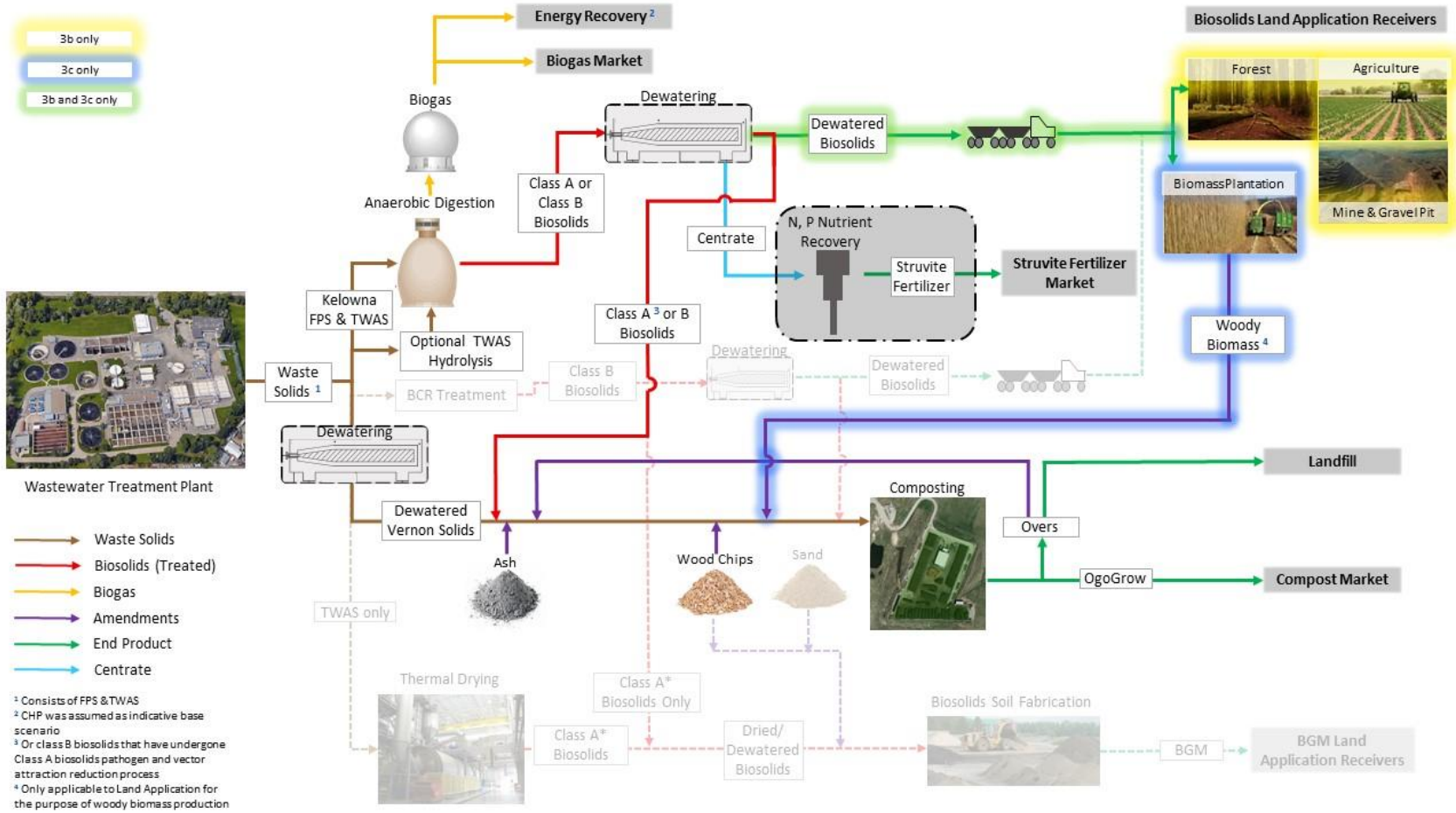

Figure 4-3: Scenario 3

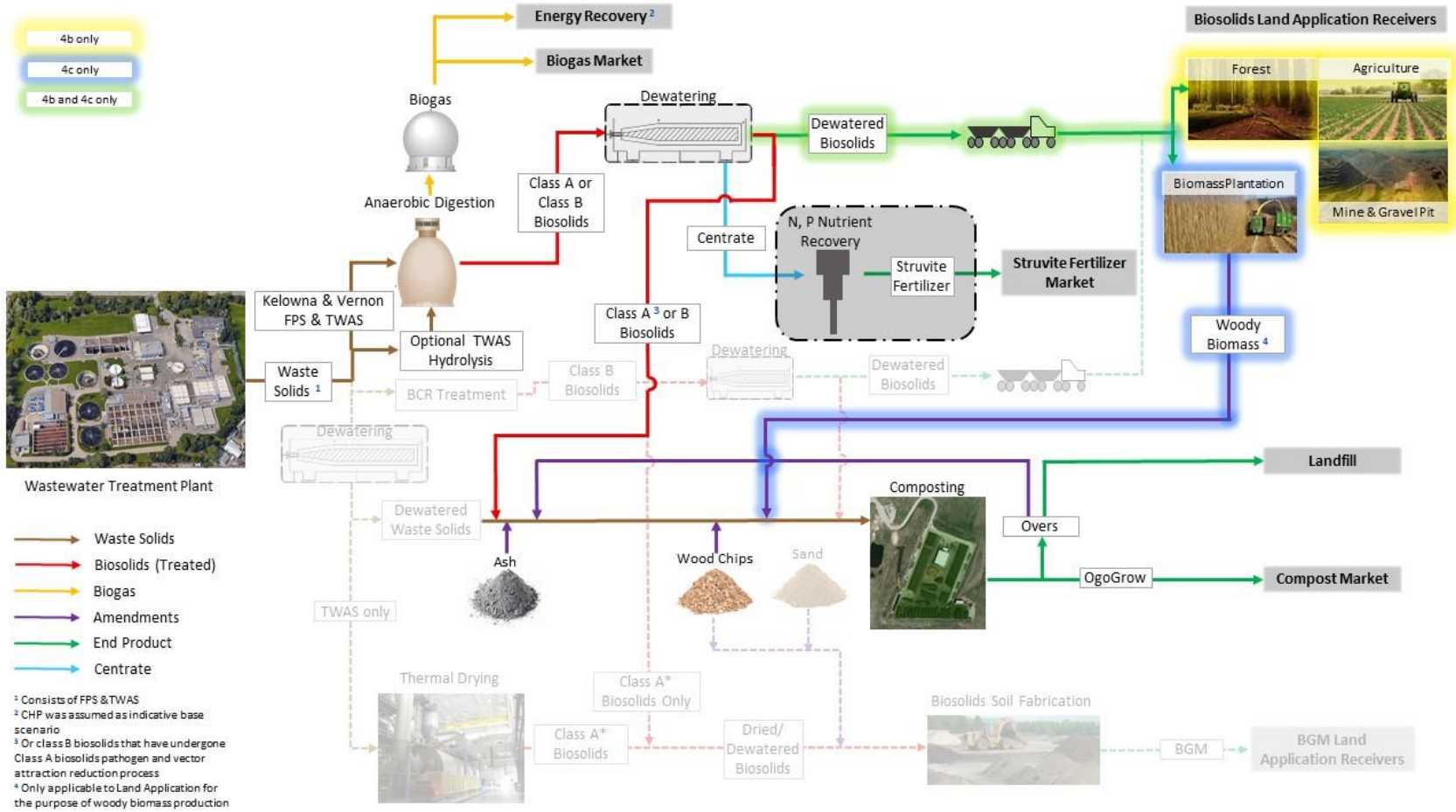

Figure 4-4: Scenario 4

Note: Struvite Recovery is only applicable to the Kelowna waste solids

5 Analysis Summary

Table 5-1 provides an overview of the analysis for the defined management scenarios. All values correspond to average monthly conditions at design year 2035. The diversion ratio of the solids to the RBCF versus land application is dictated by either reducing OgoGrow inventory or meeting compost operating demand for woody carbon.

Only scenarios 3b, 3c, and 4b achieve the objective of reducing OgoGrow inventory. For scenario 3b, it was assumed that the solids corresponding to the market cap in 2035 would be transported to the RBCF with the remainder of the solids diverted to land application. The volume of compost produced in scenarios 3c and 4b fall below the market demand in 2035. This would provide an opportunity for optimization of diversion for these two alternatives.

The woody biomass option under land application was well received in the public engagement program and it specifically addressed the risk of interrupts to the carbon feed stock at the RBCF. Therefore, the intent of scenarios 2c, 3c, and 4b was to estimate the capacity and break-even point where land application can sustain the composting operation. Scenario 4b shows that a woody biomass plantation could meet between 69 % - 100% of the carbon feedstock demand at the RBCF in 2035.

Again, variations to these base scenarios are possible which could also achieve the project outcomes – all depending on the degree of digestion and the extent of land application opportunities pursued.

Table 5-1: Management Alternatives' Analysis – 2035 Design Year

Scenario	Digestion Design Capacity (Max Month) dt/d	Digested Solids (Avg. Month) dt/y	Un-Digested Solids (Ave. Month) dt/d	Solids Sent to RBCF [f] dt/d	Solids Land Applied dt/d	Compost Produced [e] at RBCF m^3/yr	Compost Inventory Annual Change m^3/yr	Year to reach RBCF Capacity Year	Carbon Feedstock Demand at RBCF m^3/yr	Carbon Feedstock Demand Met by Biomass Plantation %	Indicative Land Application Area [d] ha/yr (Total Area, ha)
1	0		20	20.0	-	59,300	24,300	2035	165,000		-
2a	7.7	3.3	14.0	17.3	-	51,300	16,300	2028	143,000		-
2b	7.7	3.3	14.0	14.0	3.3 [b]	41,500	6,500	2043	116,000		60 to 80 (300 to 400)
2c	7.7	3.3	14.0	14.0	3.3 [b]	41,500	6,500	2043	116,000	3% - 5%	105 (315)
3a	17	7.2	7.0	14.2	-	42,100	7,100	2043	117,000		-
3b	17	7.2	7.0	11.8	2.4 [a]	35,000	-	>2065	98,000		40 to 60 (200 – 300)
3c	17	7.2	7.0	7.0	7.2 [b]	20,700	**(14,300)**	>2065	58,000	15% - 22%	180 (540)
4a	26	10.5	1.0	11.5	-	34,100	**(900)**	2057	95,000		-
4b	26	10.5	1.0	2.0	9.5 [c]	5,900	**(29,100)**	>2065	17,000	69% - 100%	230 (690)

Notes:

a) Amount that results in zero accumulation change (i.e. no increase to inventory). Land applying more would decrease inventory.
b) Equals the total digested amount.
c) Amount applied to woody biomass plantation to supply full demand of woody debris carbon supply needed for composting.
d) Land application area is hectares per year. Total area represents the sustainable land application for the period of analysis (2035 design year).
e) Based on 1 dt/yr = 8.12 m^3 OgoGrow – from 28,000 wt/yr (at 20% solids) producing 45,465 m^3 OgoGrow (Year 2015, TM-1).

Table 5-2: Management Alternatives' Analysis – 2035 Design Year

Scenario	Achieves All Project Objectives	Capital Cost			Annual Cost				Total Lifecycle [d] Cost
		Compost Capital Cost	Digestion Capital Cost [a]	Willow Plantation Capital Cost [c]	Compost O&M Cost	Digester O&M Cost	Indicative Land Application Annual Cost [b]	Total Annual Cost	
	Yes/ No	$M	$M		$M/yr	$M/yr	$M/yr	$M/yr	$M
1	No	5.8 - 6.6	-		3.4	-	-	3.4	48 – 49
2a	No	-	29.0		2.3	0.40	-	2.7	63
2b	No	-	29.0		1.9	0.40	0.32	2.6	62
2c	No	-	29.0	1.88	1.9	0.40	0.38	2.7	64
3a	No	-	48.0		1.9	1.0	-	2.9	84
3b	No	-	48.0		1.6	1.0	0.23	2.8	83
3c	Yes	-	48.0	3.17	1.2	1.0	0.82	3.0	**89**
4a	Yes	-	59.0		1.9	1.4	-	2.3	**100**
4b	Yes	-	59.0	3.82	0.4	1.4	1.08	2.9	**99**

Notes:

a) Mesophilic digestion (Class B). Location is a new location near the Kelowna WWTF. Inclusive of replacement costs required before 2035.
b) Inclusive of assessment of site suitability and development of land application plan as per OMRR, biosolids transportation within 100 km, supervision of biosolids management and post application inspection
c) Does not include the cost of land acquisition.
d) Capital plus 20 year present worth of annual cost at 3% (14.8775 factor).

6 Conclusions and Recommendations

6.1 Conclusions

a. Digestion is necessary by 2019 for any biosolids management options to meet the project objectives.
b. Digestion of both fermented primary sludge (FPS) and thickened waste activated sludge (TWAS) of Kelowna's solids will be necessary to avoid increasing OgoGrow inventory.
c. Digestion of FPS alone at Kelowna will extend the operational horizon of the RBCF (without expansion) until the year 2028 or further if some form of land application is also implemented.

6.2 Recommendations

The City of Kelowna and the City of Vernon should:

a. Continue to consider the following key factors when selecting final disposal options:
   i. Quality of life considerations such as odour, traffic, dust and convenience
   ii. Environmental sustainability
   iii. Financial sustainability
   iv. Operational and technical viability

b. Develop a comprehensive public education and public engagement program for the overall biosolids management plan to build widespread understanding of the challenges and opportunities for beneficial reuse.
c. Engage the Ministry of Health (Interior Health Authority) and the Ministry of Environment as soon as possible and keep both informed of their plans and what further specific studies are being carried forward with respect to land application potential.
d. Measure metals concentration separately in the FPS and the TWAS in addition to monitoring metals for compliance monitoring.
e. Proceed with feasibility and conceptual design of digestion at the Kelowna WWTF including:
   i. Siting for digestion facility;
   ii. Type of digestion;
   iii. Decision on whether to digest FPS and TWAS or to digest FPS only;
   iv. Selection of Class A versus Class B biosolids digestion;
   v. Evaluation of hydrolysis of the TWAS for increased mass destruction, struvite recovery, production of volatile fatty acids, biogas production, and heat recovery.
f. Defer preliminary design of digestion at Vernon WRC only after recommendations and decisions are complete related to the process treatment review of high strength industrial wastewater management.
g. Undertake further study on land application potential – especially potential for a potential woody biomass plantation, and include key factors from the stakeholder engagement work in the further development of a biosolids land application study.
h. Consider using linear programming analysis for on-going analysis and comparison of multiple outlet scenarios.

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