Liquid Waste Management Plan

Technical Memorandum

LWMP Technical Memorandum #7B

TO: Sundance Topham

SUBJECT: Treatment Options Cost Comparison

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Preface to the Revised Memo

This TM7B-Rev2 has been revised and updated from the original TM #7B, dated November 1, 2017

The major changes are to;

- Move all process description and diagrams to TM7a-Rev2
- Include a description of how the operating costs were estimated
- Include pricing information for phased and single execution of all options. The previous tm#7B did not have single project pricing for Options 1A and 1B, and did not have phased project pricing for Options 2 and 3

This memo is intended to be read in conjunction with the revised Technical Memo 7A-Rev2 – Treatment Options.

1.0 INTRODUCTION

This document provides cost estimates and a comparison between the treatment options described in Technical Memo (TM) 7A-Rev2, taking into consideration the constructability and operational aspects of each option

The costs are partially based on cost estimates developed for the November 2016 funding application using internal Tetra Tech pricing and budgetary pricing obtained by vendors. This information has also been supplemented using estimates provided by two vendors prepared in response to a Request for Proposal issued in February 2017, representing a market pricing at that time. This information, combined with other up-to-date vendor pricing, construction estimates, and standard cost assumptions, was used to produce the operating costs contained within this Technical Memo. The comparative level estimates includes a 25% contingency, and are intended and suitable for decision-making purposes in comparing options. Upon selection of a Preferred Option, more detailed cost estimate is recommended to develop a project budget.

2.0 OPTION 1 - PHASE 1 – LAGOON UPGRADE TO CURRENT PERMIT

As described in TM 7A-Rev2, Option 1 - Phase 1 is for a lagoon upgrade intended to meet both the existing Discharge Permit and Federal WSER water quality requirements.

Specific construction works and cost considerations include:

<u>Headworks</u>

The existing headworks, including the inlet channels, grinder and screen, will be replaced with minor modification or upgrade to the existing channel to incorporate a new screen. Continued use of the existing single screen will continue to allow debris and solids to bypass the screen during peak wet weather flow conditions and accumulate in the lagoons, and increase the cost of removal.

The only other recommended headworks change is to add flow monitoring for measurement of influent flows to the treatment plant for process control purposes and to provide operations staff with information on instantaneous and historical flow events.

Lagoons

The following lagoon system modifications include the design and construction of increasing the existing wastewater treatment capacity to meet the Discharge Permit and Federal WSER and water quality requirements for average dry weather flows of up to 1,800 m^3/d, and peak wet weather flows of up to 3,600 m^3/d:

1. Dredging to remove accumulated solids to recover storage volume and treatment capacity. Estimates from previous dredging of lagoons provide the basis the allowance of $500,000. This includes transport and disposal of collected biosolids.
2. Supply and install three (3) 110-m-long floating curtain baffles with anchors to create four (4) cells with approximate dimensions of 50 m x 130 m to reduce the potential for hydraulic short circuiting and, thereby, maximizing the hydraulic retention time.
3. Relocation of the four (4) existing floating surface aerators from the smaller lagoon to the larger lagoon, and supply and install four (4) additional 5HP floating aerators.
4. Construction of a hydraulic structure at the east end of the large lagoon to allow water to flow through the berm separating the large and small lagoons.
5. Installation of pre-fabricated concrete lock blocks to the lagoon walls to prevent velocity and current direction changes from eroding the existing berm wall.

Chemically Enhanced Solids/Liquid Separation

Although the lagoon improvements will increase the biochemical oxygen demand reduction capacity, algae growing in the lagoon will contribute to the total suspended solids (TSS) and BOD. To meet the Discharge Permit and federal WSER BOD and TSS requirements of less than 25 mg/L, the chemically enhanced solids/liquid separation process will treat flows up to 2,000 m^3/d. This unit process will also reduce total phosphorus concentration to meet the Discharge Permit requirement of less than 1 mg-P/L through chemical addition. The solids/liquid separation system includes tankage, pumps, and piping integral to the separation process and includes a controlled feed system for polymer and lanthanum chloride, alum, or ferric chloride. The cost estimate includes allowance for either high-rate clarification (“ballasted floc”) or Dissolved Aeration Floatation (DAF) solids separation processes.

Cost estimates for this unit process are based on previous estimates and quotations prepared for the two processes and vendor cost estimates for both 1,800 and 3,600 m^3/d capacity systems. Although the flow difference is 100% larger, the overall price difference is less than 20%. The reason is that design and control costs are similar for both capacities, and the treatment costs are not proportional to flow. These elements thus represent a more significant percentage of the total cost with lower flows.

Disinfection

The disinfection system consists of a contact tank or channel and a liquid Peracetic Acid (PAA) chemical injection dosing system to reduce fecal coliform levels to less than 200 CFU/100 mL, and includes inlet flow measurement and instrumentation/controls to monitor dosage levels and control the chemical metering pump.

Dewatering

The solids separation unit of Option 1 - Phase 1 will generate modest volumes of biosolids that require daily management. The estimate includes the supply and installation of permeable sludge dewatering bags. These will be located in disposal bins for ease of off-site transport. Polymer treatment, piping and pumps are included in this estimate and a channel to collect filtrate and return to front end of the plant.

Based on current operation and other plant experience, operational costs for desludging of the lagoons will occur on a five-year basis. Dredging lagoons is required to re-capture lost water treatment volume due to settled solids. A dewatering bag system will treat produced sludge for transport for offsite disposal.

Piping / Channels

Piping and channel work includes re-direct piping from headworks to south-west corner of the existing larger (39,000 m^3 facultative) lagoon.

1. making connections to the existing splitter box piping,
2. adding new valves and piping for raw water inflow into the larger lagoon,
3. Install cross-over channel through the berm at the south-east corner of the new aerobic lagoon to the north-east corner of the old aerobic lagoon (now facultative / stabilization lagoon), allowing water from the end of the aerated lagoon to enter the smaller 14,000 m^3 lagoon basin to the south;
4. Pipeline or channel construction from the disinfection system to a new discharge location into Maple Lake Creek.

3.0 OPTION 1 – PHASE 2A – LAGOON UPGRADE TO MEET MWR MEP

This provides the option for an indirect discharge to Maple Lake Creek involving augmenting flows to the natural wetlands bordering the north side of the lagoon meeting MEP reclaimed water quality. Option 1 - Phase 2A includes all scope defined in option 1 - Phase 1 Lagoon Upgrade with no lost investment from upgrade. The following is proposed to upgrade to meet the population and water quality needs.

Inlet Screen

A second inlet screening unit is required to meet the MWR equipment redundancy requirements. The existing concrete channel structure already includes a second channel that will require some modification to meet installation the second screen and access is required to allow movement of two disposal bins.

Chemically Enhanced Solids/Liquid Separation

A second solids separation unit is required to meet the MWR equipment redundancy requirements. Added controls for redundant control is included in this scope.

Disinfection.

An allowance has been included to increase contact time and add controls for control from the two liquid/solids processing units. This will include additional allowance for control to multiple feed points.

Dewatering

An allowance is included to provide additional interconnection to the bag dewatering system highlighted in Option 1.

Natural Wetlands Distribution

The estimate includes an allowance to add a pumping conveyance system to move treated water to wetland area to the north, and then a system of subsurface distribution. A low head transfer pump station and an infiltration trench are assumed, though there are other ways of doing the water distribution such as mulch beds and subsurface drip irrigation. It should be noted that an allowance to include operator access roads that will also include some allowance for walking trails and other public amenities, and habitat enhancement such as invasive plant removal and tree planting.

The wetland distribution is conceptual at this stage, and is not developed to the same level as the treatment system options. A feasibility study with site investigations and hydraulic testing and modelling are needed to complete the scope of this system.

The north wetland system can be added to any of Option 1 – Phases 2A or 2B, or Options 2 or 3, but it is required for Option 1 – Phase 2A.

4.0 OPTION 1 – PHASE 2B – LAGOON UPGRADE TO MEET MWR GEP

This option considers that the current Discharge Permit would no longer be in effect and the discharge would need to comply with the provincial MWR GEP water quality requirements. Phase 2B includes all scope defined in Option 1 - Phases 1 and 2A Lagoon Upgrades with full integration of previous upgrade.

Fine Screening

The MWR GEP BOD concentration requirements of less than 10 mg/L are considerably lower than the 25 mg/L requirement for the existing Discharge Permit or the MWR MEP. While the extra reduction in BOD could be achieved through extended additional biological treatment, a lower cost approach is to reduce the BOD loading to the plant.

Fine screens and chemically enhanced primary separation have been selected to reduce the BOD loading in the order of 30 percent or more, thereby reducing the BOD loading to the lagoons and reduce the effluent BOD concentrations following treatment. Two fine screens are included to meet the MWR equipment redundancy requirements.

The fine screens will be designed for a hydraulic flow of up to 3,600 m^3/d. As flows above the design capacity greatly degrade the performance of primary solids removal, flows in excess of 3,600 m^3/d will be bypassed around the fine screens into the lagoon.

Lagoon Upgrade

The plant will need additional treatment to achieve ammonia nitrification. The estimate includes and allowance to add suspended Ringlace media (or equivalent) to the facultative lagoon. If the north wetlands distribution is being implemented, it is possible that ammonia removal will occur in the wetland, as is currently occurring in the natural wetlands of Maple Lake Creek. This will need further investigation.

Filtration

The MWR also has an average turbidity water quality requirement of 2 NTU and a maximum of 5 NTU. High quality filtration in the form of, for example, chemically enhanced sand filtration, ultrafiltration membranes, or disk filters, are required to consistently achieve the required turbidity levels. Similar to the fine screens, the filtration system will be designed for a hydraulic flow of up to 3,600 m^3/d. As the filters inherently impede water flow and have hydraulic flux limitations, flows above the design capacity result in excessive head losses. Consequently, flows in excess of 3,600 m^3/d will be bypassed around the filtration system. Two filtration units are required to meet the MWR equipment redundancy requirements.

5.0 OPTION 2 - BASEFLOW MECHANICAL TREATMENT

Option 2 involves constructing a mechanical biological treatment process to treat up to 3,600 m3/d of wastewater to a MWR GEP water quality standard to allow continued discharge to Maple Lake Creek as a stream augmentation beneficial reuse application. Flows in excess of 3,600 m3/d would be diverted through the existing lagoon treatment system in its current configuration, with an allowance to remove accumulated sludge from the lagoons as part of the construction program. Specific elements include:

Headworks

In this phase, the headworks including the inlet channels will house two news screens for primary screening.

Fine Screens

As the membranes require finer removal, a fine filter screen will be installed after the coarse screen. The fine screen will not provide reliable service for the high inflow and infiltration solids typical with a combined collection system. Consequently, flows in excess of the design capacity of 3,600 m^3/d will be bypasses around the fine screens and diverted to the existing lagoon system. The two fine screen units will be provided to comply with the MWR redundancy requirements.

Membrane Bioreactor

The addition of a packaged MBR will be aligned with the original approach as verified by one of the vendor submissions from the Feb 2017 RFP. As noted, the MBR process incorporates ultrafiltration membranes for solids/liquid separation TSS removal, as well as colloidal particle (turbidity) removal.

Peracetic Acid Disinfection

The disinfection system consists of a contact tank and a liquid Peracetic Acid (PAA) chemical injection dosing system. The ultrafiltration membrane will reduce the number of fecal coliform levels to less than the detection limit. The membrane-based treatment will not have a similar effect in reducing any viruses that may be present. A Peracetic disinfection system will be added and disinfection efficacy will be based on concentration and time (CT) criteria using inlet flow measurement and instrumentation/controls to monitor dosage levels and control the chemical metering pump.

Dewatering

Option 2, with a higher level of treatment, will generate larger volumes of biosolids that will have to be managed on a daily basis. An allowance has been included for the supply and installation of permeable sludge dewatering bags. These will be located in disposal bins for ease of off-site transport. The dewatering performance is adversely affected but the ease of operation offsets the reduced performance. Piping and pumps are included in this estimate and a channel to collect filtrate and return to front end of the plant.

The original estimate allowed for a fully automated – batch dewatering system. The operational cost for the dewatering bags is higher but the capital cost aligns better for the phased approach. In subsequent stages, a business case could confirm the operational and cost advantages for upgrade. With treatment to these design flows and proximity to a landfill would likely prove bag dewatering as a good approach. Detailed analysis of the comparison is reserved for future study. Additionally, this cost-effective approach is part of the approach to create an affordable upgrade option

Option 2 can also be implemented after an Option 1 – Phase 1 lagoon upgrade. All of the Option 1 - Phase 1 works, except the lagoon aeration upgrade, are part of the baseflow mechanical scope. There are additional indirect costs incurred for executing a second project.

6.0 OPTION 3 - FULL FLOW MECHANICAL TREATMENT

The Full Flow Mechanical treatment option was developed when seeking grant funding in November 2016. The concept was to have the entire peak flow of 14,400 m^3/d treated to a secondary level, and tertiary (filtration) treatment up to the peak summer flow of 3,600 m^3/d. These are the same flow parameters developed in TM#3 using historically based projected flows and loads.

A conservative capital cost estimate was developed for the funding application using internal Tetra Tech pricing and budgetary pricing obtained from vendors. An RFP for the process equipment was issued in February 2017, but cancelled when the grant funding was not received. However, in response to the tender call, two vendors progressed their estimate to completion based on the RFP, and provided those estimates to the Village of Cumberland, for future consideration. These proposals represent a market-based price to replace the original estimates used in November 2016.

The following provides a summary of the two received estimates using the same scope element as the initial estimate and a comparison to the phased approach as described in TM 7A

Vendor A proposed a Membrane Bioreactor (MBR) system, and Vendor B a Moving Bed Biofilm Reactor (MBBR) system. Both estimates in response to the RFP appear to be close in price – within the accuracy of the estimate. The primary savings is found with the chemically enhanced separation component, where the indicative design assumed use of a ballasted flocculation process. This process accounted for 13% of the overall cost.

In the case of vendor A's MBR process, separation is integral with the membrane system. Vendor B with the MBBR used a less costly Dissolved Air Floatation (DAF) separation system supplied in a modular nature and installed on site by vendor staff.

The contingencies associated with multiple supplier alignment were also reduced. The original estimate included larger allowances for multiple suppliers providing process elements. The two bids provided supply with one organization thus providing more cost certainty.

Option 3 can also be implemented after an option 1 – Phase 1 lagoon upgrade, but with some redundancy of phase 1works. The lagoon aeration upgrade and the Option 1 – Phase 1 solids separation unit are not part of the single-phase full-flow mechanical scope and represent additional costs. There are also additional indirect costs incurred for executing a second project.

7.0 REED BED

The reed bed is an optional component, and is not needed to meet regulatory or capacity requirements. The budget excluding the reed bed represents the minimum capital cost for a complete project, and including it gives the comparisons for the project as envisioned in November 2016.

The reed bed costs included here are based on data obtained from a study reporting on a similar lagoon and reed bed system serving a community in Australia. The study found the reed bed reduced BOD and TSS concentrations by an average of 22 mg/L and 8 mg/L, respectively, with an average loading rate of 70 mm/day, with similar reductions during wet weather overload conditions of 210 mm/day. The Cumberland reed bed design estimate assumes a 210 mm/day loading rate for peak summer flow of 3,600 m^3/d, equating to 1.7 ha of reed bed, or about 2/3 the size of the larger lagoon. The project cost reported for the Australian reed beds was $2.5M for a 6 ha reed bed in 2000.

The estimate presented here assumes the reed bed costs are linear to overall size. In factoring size to 2 ha and 50% for inflation, this provides a confirmation of the previous allowance of $1.5M. The final cost includes 25% contingency for a total an allowance of $1.9 M. An annual operating cost allowance would be $25,000 for pumping, inspection and minor maintenance.

As the reed bed is completely discretionary, and can be added to any treatment option at any time, its cost has not been included with any of the options. Strategically, the Reed Bed addition does present a phased option that would be better fit for grants focusing on innovative and energy efficient processes. The Reed Bed is broken out as the best potential for affordability is to add the Reed Bed subject to alternate grant programs thus reducing the tax burden.

8.0 OPTION OPERATIONAL COSTS

Operating cost estimates have been developed for all the treatment options. They include;

- Operators
- Electricity
- Process Chemicals
- Biosolids disposal
- Regular maintenance
- Allowances for membrane replacement, were applicable
- Operating the wetland, for Option1A

Operating costs for the mechanical plants are based partially on operating costs from the Sechelt Water Resource Centre, with appropriate allowances for differences. Lagoon operating costs are based on current costs and standard estimates for cost of operating additional treatment elements like the chemically enhanced separation. It is important to note that the chemical cost for solids separation is an integral part of all Options, including Phase 1.

The operating costs for the lagoon options includes an allowance for dredging of biosolids every 5 years at a cost of $500,000.

The operating costs are comparative estimates to provide an indication of the relative costs of adding chemical treatment and increasing power demands due to addition of mechanical equipment. The estimate includes an allowance for mid-life (15-year) capital replacement of process equipment but excluding tankage. The MBR option assumes membrane replacement every 7.5 years of operation.

Operating costs for the wetland distribution –estimated to be $25,000 per year - have been included in Option 1, Phase 2A only.

None of the options include a cost for operating the reed bed, though this cost is expected to be similar to the wetlands distribution.

9.0 OPTION COST COMPARISON

The capital costs for Option 1 - Phase1 and all other Phases and Options are presented in Table 1 for both one and two-phased execution. The wetland is shown as an addition to all Options, as it is possible that Ministry of Environment might require and accept it as an alternate discharge location to the direct discharge to Maple Lake Creek.

Table 1. Cost Comparisons for all Treatment Options.

	Option 1			Option 2	Option 3
	Phase 1	Phase 2A	Phase 2B		
Capital Cost for one-phase execution	n/a	$8.7M*	$10.6M	$ 9.3 M	$14.8 M
Capital cost for two-phased execution	$5.6 M	$9.5M*	$ 11.7M	$10.2M	$16.3M
Capital cost for two phases, with wetland	$6.6M	$9.5M	$12.7M	$11.2M	$17.3M
Operating Cost	$350k	$375k	$425k	$450k	$500k

- Includes the wetland as this is integral to Option 1A

Table 2 provides a technical comparison of the options presented above. There are two comparisons for effluent quality: 1) "design"; and 2) "target". Design is what is required to be met, for regulatory compliance, across the entire design flow range. Target effluent quality is what is expected under normal operating conditions of Average Dry Weather Flow, as is seen in the real-world operation of most treatment plants.

Other comparisons (energy, complexity, carbon footprint) are made on a qualitative basis, to indicate the differences between the systems.

Table 2. Technical comparison of Treatment Options

	Present System	Option 1			Option 2	Option 3
		Phase 1	Phase 2A	Phase 2B		
Description	Aerated and Facultative Lagoons	Upgraded Lagoon to Permit Compliance	Upgraded Lagoon to MEP	Upgraded Lagoon to GEP	Base flow mechanical to GEP	Full flow mechanical to GEP
Population capacity	<4,000	5,000	7,000	7,000	7,000	7,000
Discharge Location	Maple Lake Creek	Maple Lake Creek	North Wetlands	Maple Lake Creek	Maple Lake Creek	Maple Lake Creek
Effluent Quality (BOD-TSS, mg/L)	25-25 (winter) 50-50 (summer)	25-25	25-25	10-10	10-10	10-10
Disinfection by PAA	None	<200CFU/100 mL	<100CFU<100 mL	<1CFU/100mL	<1CFU/100mL	<1CFU/100mL
Biosolids Withdrawal	Periodic dredging (last done 2009)	Periodic dredging + low vol. continuous	Periodic dredging + low vol. continuous	Periodic dredging + low vol. continuous	Continuous	Continuous
Operational Class	1	2-3	2-3	3	4	3-4
Energy use	Low	Moderate	Moderate	Moderate	High	Highest
Carbon Footprint	Very Low	Low	Low	Low	High	Highest
Land Reclaimed	No	No	No	No	No	Yes –Lagoons 4Ha