# Liquid Waste Management Plan

# Technical Memorandum

**LWMP Technical Memorandum #7A-Rev2**

**TO:** Wastewater Advisory Committee

**SUBJECT:** Treatment Options

**DATE:** November 29, 2017

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**Preface to the Revised Memo**

This TM7A-Rev2 has been revised and updated from the original TM #7A, dated November 1, 2017

The major changes are to;

- Include some process description and diagrams that were previously in TM#7B
- Update the naming system for the Options. There is now;
    - Option 1 Upgraded Lagoon
        - Phase 1 - for Permit Compliance
        - Phase 2A, for MWR compliance and MEP water quality
        - Phase 2B, for MWR compliance and GEP water quality
    - Option 2 Baseflow Mechanical
    - Option 3 Full Flow Mechanical
- Add site diagrams for Options 2 and 3
- Include explanation of phasing concept for all Options

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

## 1. BACKGROUND

The Village of Cumberland has over 50 years of lagoon effluent water quality and receiving environment water quality monitoring data that was collected and reported in compliance with the Discharge Permit requirements, but not analyzed as a means of assessing the treatment characteristics and performance of the lagoons. In order to better understand how the existing treatment lagoons are performing, a number of modifications were made to the monitoring programs, and the modified program was carried out this past summer as described in TM#4. The changes included collecting water quality samples between the two lagoons, additional stream water quality samples, in-stream flow measurements, and additional analytical parameters in order to better understand the treatment characteristics, capacity and performance of the existing lagoon system, and of the downstream natural wetlands along Maple Lake Creek. This work has enabled the project team to better understand the lagoon system treatment capacity, consider methods to enhance and upgrade the level of treatment achieved, and consider cost-effective means to benefit from the lagoon system as a wastewater treatment component for long-term community wastewater treatment planning.

The treatment options presented in this technical memo take into consideration:

- Discharge options described in TM #6,
- Raw water quality and quantity,

- Necessary improvements to achieve and maintain compliance with required water quality levels.

The three primary upgrading approaches discussed in this document are as follows:

### 1.1. <u>Option 1 - Lagoon-Based Treatment</u>

#### 1.1.1 Existing Lagoon Performance

The basic concept is to optimize the treatment performance and capacity of the existing lagoons as the primary means of biological treatment with the focus on reduce the soluble biochemical oxygen demand (BOD) and meet the existing Discharge Permit water quality requirements. With that accomplished, a second phase can be carried out at some point in the future to expand treatment capacity and meet MWR requirements by adding mechanical equipment components.

The 2017 modified monitoring program described in TM#4 provided information on the degree of treatment being achieved by each of the two lagoons and better insight on future performance under increased loading than is possible using generic lagoon system design equations.

The BOD analytical test provides information on how much oxygen will be consumed by bacteria in digesting the organic matter present in the water. Some of this organic matter is dissolved in the water, and some are solid particles that are slowly consumed by the bacteria during the 5-day test period. When there is an algae bloom, the proportion of the BOD associated with solid particles is very high. The 2017 monitoring program showed that if the algae and other total suspended solids (TSS) particles were removed using a mechanical solids/liquid separation component, the remaining soluble BOD and the TSS in the effluent would be less than 10 mg/L, under current population loading conditions; well below the current Discharge Permit BOD and TSS criteria.

#### 1.1.2 Phase 1 Lagoon System Improvements – Meeting Discharge Permit Requirements

In order to maintain the effluent water quality as the contributing population increases, it is necessary to increase the treatment capacity. This can be achieved by optimizing the treatment performance of the existing lagoons and by adding mechanical equipment.

The lagoon BOD removal can be optimized by: 1) installing additional aerators to increase the amount of oxygen applied to the treatment process; 2) increasing the effective aerated volume of water by aerating the larger lagoon instead of the smaller lagoon; and 3) maximizing the retention time for biological treatment by installing floating baffles or curtains. The strategically placed floating baffles prevent water from entering one end of the lagoon and flowing immediately and directly to the exit by directing the flow pattern back-and-forth across the lagoon. Implemented as a single initial phase of work, Phase 1 focusses on achieving the necessary BOD, TSS, total phosphorus, and indicator bacteria water quality reductions to comply with the Village's current Discharge Permit requirements and allow the performance of the upgraded system to be evaluated and verified before further modifications are considered and implemented. In addition to modifying the lagoons to enhance biological treatment and add solids separation, disinfection capacity will be added to treat for both summer and winter flows.

#### 1.1.3 Phase 2 Lagoon System Improvements – Meeting MWR Discharge Requirements

##### *1.1.3.1 Triggering*

It is expected that Cumberland will eventually need to bring the discharge into compliance with the MWR, which will require a second phase of upgrades.

While the Discharge Permit was grandfathered, significant changes to the discharge conditions could cause the Ministry to require the community to meet MWR conditions. Potential triggers include a request for a significant increase in the permitted average annual daily discharge, which is currently 910 $m^3$/d, or a desire to reuse reclaimed water.

*1.1.3.2 Phase 2 Objectives*

Phase 2 improvements will need to accommodate population growth while continuing to meet the water quality requirements of the existing Discharge Permit, the federal WSER and the provincial MWR Moderate Exposure Potential (MEP) water quality standards over the design flow range. As the existing lagoons have only a finite capacity to remove BOD, rather than increase the size of the lagoons to handle future BOD load increases, a more cost-effective method of BOD reduction in the form of primary solids separation is proposed. Further, with the addition of tertiary effluent filtration equipment, the upgraded lagoon system can also meet the more stringent provincial MWR Greater Exposure Potential reclaimed water quality standard.

Wastewater flows in excess of 3,600 $m^3$/d can also be treated through the upgraded lagoon system, but will be bypassed around the mechanical solids/liquid separation and filtration stages, with the excess flow being routed directly from the lagoons to disinfection prior to discharge.

In addition to meeting discharge water quality requirements, Cumberland will also need to meet the equipment redundancy and back-up power requirements under the MWR for both Phase 2 discharge alternatives. It is expected the upgrade design Average Dry Weather Flow (ADWF) will be 1,800 $m^3$/d, with the plant designed to meet provincial MWR requirements for wastewater flows up to 2xADWF (3,600 $m^3$/d) for both Phase 2A and 2B, as well as Options 2 and 3.

*1.1.3.3 Two Discharge Locations and Associated Water Quality Alternatives*

Once a requirement to Register the Discharge under the MWR is triggered, taking into consideration the near complete absence of dilution in dry weather in both MLC and the Trent, it is expected a continued discharge into MLC will need to meet the MWR Greater Exposure Potential (GEP) water quality criteria.

Cumberland was directed by the Ministry of Environment to consider alterative discharge locations. The wetlands located to the north of the lagoons (referred to as the north wetlands) is a possible alternative discharge location. A wetlands discharge without immediate or direct public access would require a water quality essentially the same as is currently required by the Discharge Permit, and is referred to as a Moderate Exposure Potential (MEP) reclaimed water quality.

*1.1.3.4 Two Alternative Phase 2 Treatment Alternatives: 2A and 2B*

The two discharge locations and associated water qualities are reflected in the following Phase 2 alternatives: 1) Phase 2A to achieve a MEP water quality with a discharge to the north wetlands; and 2) Phase 2B to achieve a GEP water quality with continued discharge to MLC.

*1.1.3.5 Phased Approach or Single Phase*

The lagoon improvements can be done in phases or as a single project. The gives the community flexibility to chart an affordable and fiscally responsible path to meet the ultimate goal of servicing a future population of 7000 people while meeting all applicable requirements of the provincial Municipal Wastewater Regulation.

*1.1.3.6 Other Second Phase Alternatives*

The phased approach, beginning with a first phase lagoon upgrade, can be followed up by any of the mechanical equipment options in a second phase. Alternatively, if sufficient funding is available, the Phase 1 lagoon upgrade can be rolled into any of the Options to make a single upgrade project. All of Phase 1 scope is required for all options except the Full Flow Mechanical option.

### 1.2. Option 2: Baseflow Mechanical Treatment

This option provides mechanical treatment and disinfection capable of achieving a MWR GEP reclaimed water quality suitable for beneficial stream augmentation into MLC without the need for dilution, for a design ADWF of 1,800 $m^3$/d and wet weather flow of up to the 3,600 $m^3$/d. All excess wet-weather flows beyond 3,600 $m^3$/d would be directed through the lagoon treatment system. All flows, whether mechanically treated or directed through the existing lagoon system, are disinfected prior to discharge to MLC under this option.

### 1.3 Option 3: Full Flow Mechanical Treatment

This option also provides mechanical treatment and disinfection capable of achieving a MWR GEP reclaimed water quality suitable for beneficial stream augmentation into MLC without the need for dilution, for a design ADWF of 1,800 $m^3$/d and wet weather flow of up to the 3,600 $m^3$/d. It also provides mechanical treatment, and disinfection, to achieve a secondary water quality for excess flows up to 14,400 $m^3$/d . This option provides treatment for the high winter flows where there is major inflow and infiltration, and the lagoons could be decommissioned or re-purposed.

This approach is similar to the proposed treatment process developed In November 2016, in response to a grant funding opportunity. This was deemed the preferred option at the time based on meeting the GEP potential in summer and current Discharge Permit water quality conditions in the winter, plus it could be constructed within the 1-year timeline limitation stipulated within the grant. The funding application was unsuccessful, and in 2017 all treatment options were re-considered.

### 1.4 Reed Bed

The 2016 treatment concept also considered the construction of an engineered wetland, referred to as a “reed bed”, using a charcoal media (biochar) to remove emerging contaminants, including pharmaceuticals, from the treated wastewater effluent. This option is described briefly in the upgraded lagoon approach, and in more detail in TM #9 Reed Bed. It is not needed to meet any regulatory requirements, and can be considered an optional addition to any of the treatment options presented.

## 2. OPTION 1 – LAGOON-BASED TREATMENT SYSTEM

### 2.1 Consideration for Lagoon-Based Treatment Systems

There is an old adage of “not throwing the baby out with the bathwater”. In this case, the baby is the lagoons that have served and continue to serve the community well. For those who feel they need to acquire the latest electronic gadget, basing future community wastewater needs on a treatment technology that is over a century old must seem very antiquated. This is further underscored by the knowledge that the community’s treated wastewater discharge has been out of compliance with the Discharge Permit from the date it was issued – giving the appearance that it must be the technology that is at fault.

However, for small communities, where there is sufficient land available, lagoon treatment is often the lowest cost method of BOD reduction, particularly when labour and power costs are taken into consideration. That is not to say a lagoon-based treatment would not require maintenance, but it would require significantly less daily operator attention than a mechanical treatment process. Further, lagoon systems, because of their characteristically long hydraulic retention times, can better handle wide variations in wastewater flows, resulting in a more stable effluent water quality, than higher rate mechanical processes. The long hydraulic retention time within the lagoons has served the community well with the high inflow and infiltration (I&I) that the community experiences. The ability to accept large variations in wastewater characteristics makes lagoon systems a particularly attractive treatment technology for Cumberland.

The Village of Cumberland also has considerable experience operating and maintaining the lagoon system and is fortunate to have access to a large body of land, including natural wetlands located adjacent to the lagoons and downstream along Maple Lake Creek. The Lagoon Upgrade approach builds upon the successes and strengths of the existing lagoon system.

Lagoon systems can also have a number of disadvantages that may affect their selection as a treatment technology, including:

- Design is typically based on a conservative interpretation of performance data obtained from a wide variety of lagoon systems;
- Lagoon systems are less efficient than mechanical processes in cold climates due to the large amount of heat loss that occurs as a result of the long hydraulic retention times and large surface area for heat loss;
- Lagoons can provide a breeding area for mosquitoes and other insects;
- Odour can become a nuisance as a result of turn-over in the spring;
- Lagoons typically have limited ammonia and phosphorus removal.
- Lagoons have trouble meeting regulatory effluent TSS requirements due to algae

### 2.2 2016 Federal Funding Grant Considerations

Continued and expanded use of the lagoon system was considered for the 2016 federal funding grant application; however, it was ruled out as an option due to a number of factors, including:

- Historical effluent water quality data indicated both BOD and TSS exceeded the Discharge Permit secondary effluent requirements;
- A capacity review using conventional lagoon design criteria concluded the lagoons had limited residual capacity to handle additional wastewater loading without considerable modification including enlargement and deepening;
- Based on the capacity review, expanding the lagoon treatment to serve a population of 7000 required extensive excavation, necessitating a geotechnical evaluation to assess feasibility that could not be completed within the limited amount of time available to prepare the grant-funding application.

### 2.3 Addressing Key Lagoon Effluent Quality Limitation – Solids Separation

The failure to obtain the federal funding grant allowed further exploration of options to upgrade treatment to meet future population demands, and resulted in a recommendation to analyse the lagoon performance in greater detail than had been previously done, as well as verify downstream environmental conditions. As noted previously, the enhanced monitoring program carried out in 2017 demonstrated the inability to meet the Discharge Permit BOD criteria was primarily due to the presence of algae and other suspended solids and that, by introducing a mechanical solids/liquid separation stage, both the BOD and TSS would be well below the Discharge Permit requirements. The data gathered this summer demonstrated the smaller aerated lagoon with a 14-day Average Dry Weather Flow (ADWF) hydraulic retention time is reducing the soluble BOD concentrations to less than 10 mg/L. This means that if solids separation were incorporated into the treatment process after lagoon treatment, both BOD and TSS would be less than 10 mg/L under current population loading conditions.

### 2.4 Phasing Lagoon-Based Treatment Improvements

The regulatory requirements described in TM#1 Regulatory Framework are summarized in Table 1, and correspond to two phases: 1) Phase 1 to meet current Discharge Permit requirements; and 2) Phase 2 to meet MWR requirements at some point in the future. As previously noted, because there are two potential discharge locations that have been identified, each with different prospective effluent water quality requirements under the MWR. Phases 2A and 2B represent two different second phase upgrades that meet the MWR requirements for two different discharge scenarios while accommodating population growth projections for the next 20-years, as does mechanical Options 2 and 3.

The Lagoon-based treatment system option can achieve full MWR compliance in a single phase or it can be phased into two upgrades to meeting funding limitations. Both the Phase 2A and 2B alternatives shown in Table 1 are based on Phase 1 being completed.

*Table 1 Option 1 - Phased Lagoon Upgrade Targets*

| | Option 1 – Lagoon-Based Treatment System | | |
|---|---|---|---|
| | **Phase 1** | **Phase 2A** | **Phase 2B** |
| Purpose | Meet Current Permit | Meet MWR MEP | Meet MWR GEP |
| Discharge to: | MLC | North Wetland | MLC |
| Authorized ADWF ($m^3$/day) | 910, may be increased to 1000 | 1800 | 1800 |
| Implied population capacity | 5,000 | 7000 | 7000 |
| Design peak flow for disinfection | 14,400 ($m^3$/day) | 14,400 ($m^3$/day) | 14,400 ($m^3$/day) |
| Design peak flow for hydraulic components | 2000 ($m^3$/day) | 3,600 ($m^3$/day) | 3,600 ($m^3$/day) |
| BOD (mg/L) | ≤ 25 | ≤ 25 | ≤ 10 |
| TSS (mg/L) | ≤ 25 | ≤ 25 | ≤ 10 |
| Total Phosphorus (mg-P/L) | < 1 | < 1 | < 1 |
| Orthophosphate (mg-P/L) | n/a | < 0.5 | < 0.5 |
| Fecal Coliform (CFU/100 mL) | < 200 | < 100 (median)<br>≤ 400 (maximum) | < 1 (median)<br>≤ 14 (maximum) |
| Turbidity (NTU) | n/a | n/a | ≤ 2 (average)<br>≤ 5 (maximum) |
| Un-ionised ammonia (mg/L) | < 1.25 | < 1.25 | < 1.25 |
| Redundancy | Limited – Disinfection only | Multiple units for all processes | Multiple units for all processes |

### 2.4.1 Option 1 - Phase 1 – Meet Current Discharge Permit Requirements and Conditions

Option 1, as previously noted, involves upgrading the performance and treatment capacity of the existing lagoons to serve as the primary means of BOD reduction in a two-phase process. The first phase involves optimizing the performance of the existing lagoons and adding solids removal and disinfection equipment for the purpose of meeting the current Discharge Permit requirements as shown in Figures 1 and 2, The second phase involves additional mechanical equipment to further increase the treatment capacity as well as meet redundancy requirements under the MWR. There are two alternative second phases that have been developed for Option 1, each corresponding to a different discharge location and associated water quality requirement; however, either of the two other Options (i.e. 2 or 3) could also be implemented as a second phase following Option 1 Phase 1, if so desired.

It is assumed that the Ministry of Environment will grant a request for a minor amendment to the Discharge Permit to increase the authorized average discharge, interpreted here as the Average Dry Weather Flow (ADWF) from the current 910 $m^3/d$ to a flow of 1,000 $m^3/d$. The purpose of the request for the minor amendment to the Discharge Permit is to provide the community with additional time to plan and obtain funding for a second phase upgrade to bring the discharge into compliance with the MWR.

The process configuration for Option 1

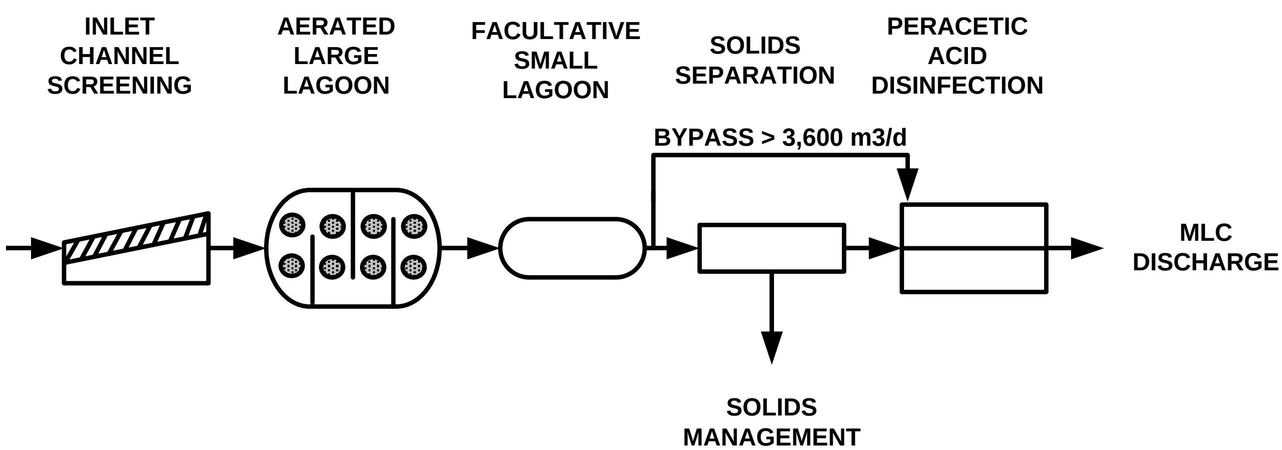


**Figure 1 – Option 1 – Phase 1 - Lagoon Upgrade to Meet Discharge Permit Requirements**

Option 1 – Phase 1 involves modifying the existing lagoons to improve their BOD reduction performance and provide a more robust approach to meeting the existing Discharge Permit conditions.

This would involve the following changes:

- Minor improvements to the headworks area – storage, security, instrumentation and flow measurement
- Increased aeration and aerated hydraulic retention time to treat increased BOD loading from future populations. This includes increasing the aerated lagoon size by converting the existing larger facultative lagoon to an aerated lagoon, increasing the number of surface aerators, and adding baffles to reduce the potential for hydraulic short circuiting (i.e. optimizing lagoon treatment);

- Converting the existing smaller aerated lagoon into a facultative (stabilization) lagoon.
- Adding a chemically enhanced solids/liquid separation unit to remove algae and suspended solids to achieve an effluent total suspended solids concentration of less than 25 mg/L; This will also provide for phosphorus reduction through chemical addition (i.e. lanthanum chloride, alum, or ferric chloride) to the solids/liquid separation process.
- Supply and install permeable dewatering system for managing collected sludge from the solids/liquid separation system
- Add disinfection using Peracetic Acid (PAA) to reduce fecal coliform levels to < 200 CFU/100 mL.

Figure 2 illustrates a proposed reconfiguration of the existing lagoon system to achieve the above upgrades.

If needed, it is envisioned the work could be done on an incremental basis with the highest priority being the indicated modifications to the larger lagoon, adding disinfection, followed by the solids/liquid separation process.

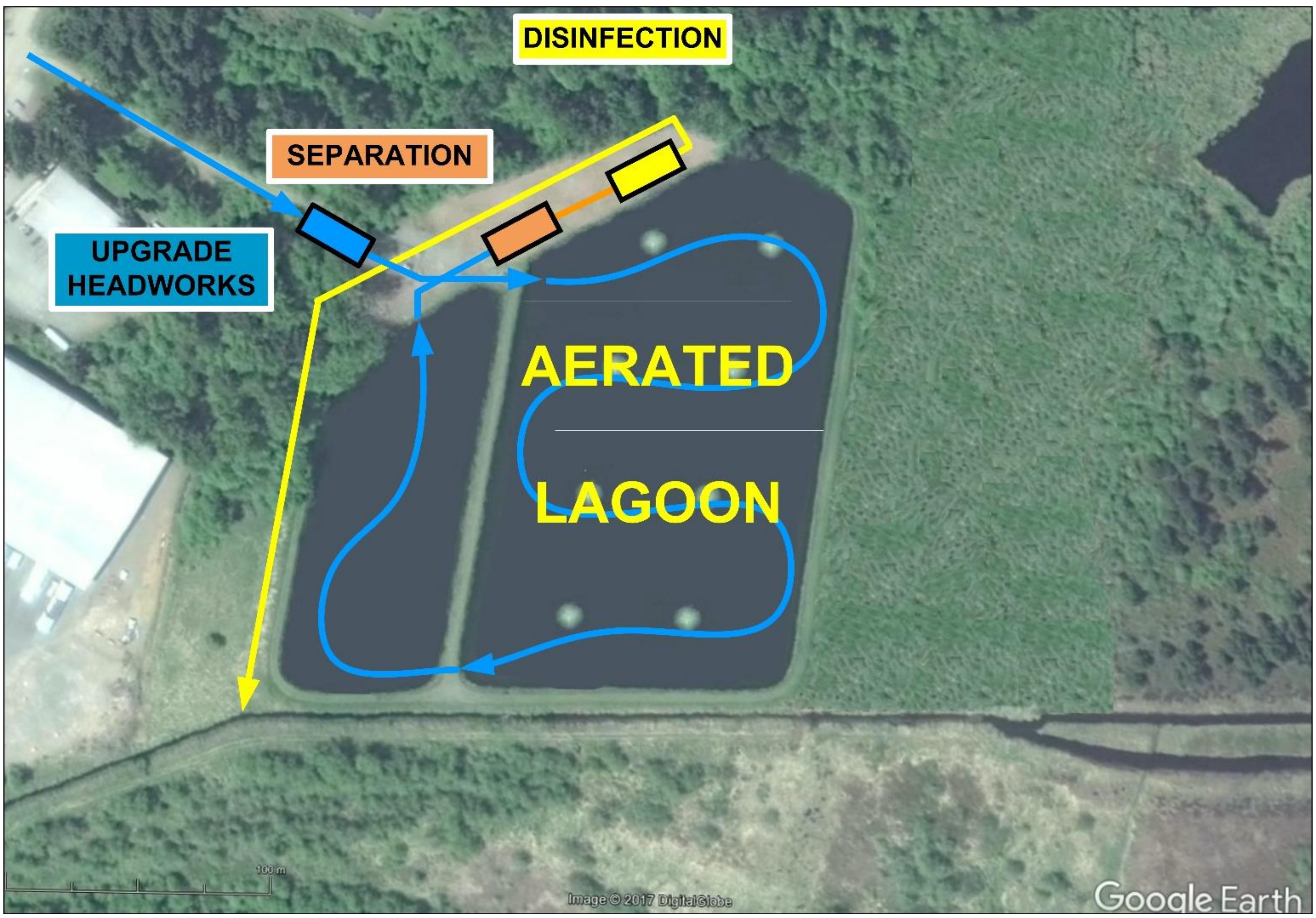


*Figure 2  Lagoon Upgrade to Meet Discharge Permit Requirements*

Redundancy is not a requirement of the current Discharge Permit conditions and authorized works, but the disinfection system will be designed to meet the redundancy requirements under the MWR. The reason for not including redundancy in the solids separation component is that:

- some solids separation redundancy is provided by the smaller facultative lagoon;
- mechanical failure requiring the solids separation unit to be taken off-line for an extended period of time is considered to be unlikely;
- as a short-term priority cost control measure, solids separation following a large settling basin is the least most critical treatment component; and
- additional redundancy will be provided in conjunction with Phase 2 upgrades..

Option 1 Phase 1 has been designed such that either Option 1 Phase 2A or 2B, or Options 2 or 3 can be carried out as a second phase with little or no loss of benefit from the Phase1 works.

The Phase 1 upgrade is intended to optimize the performance of the existing lagoons and meet the existing Discharge Permit requirements by: 1) increasing the aerated volume of water and the hydraulic retention time; 2) providing mechanical secondary solids separation with chemical addition to remove suspended solids and phosphorus; and 3) providing for disinfection. By targeting an effluent quality with BOD & TSS less than 25 mg/L the upgrade will also enable the discharge to meet the new federal WSER requirements.

Phase 1 is a meaningful upgrade that achieves regulatory compliance with the current Discharge Permit and represents the least cost to the community.

### 2.4.2 Option 1 - Phase 2 – Meet MWR Requirements and Conditions for 20-Year Projection

#### *2.4.2.1 Phase 2A: Lagoon Upgrade to MWR MEP with Wetlands Augmentation*

This second phase alternative for Option 1 is intended to meet the MWR registration requirements for MEP for discharge to the north wetlands. Illustrated in Figures 3 and 4, this alternative involves also increasing the baseflow (up to 3,600 m$^3$/d) for to augment flow through the wetlands. Excess flow over 3600 m$^3$/d (winter flows) would discharge direct to Maple Lake Creek, following disinfection.

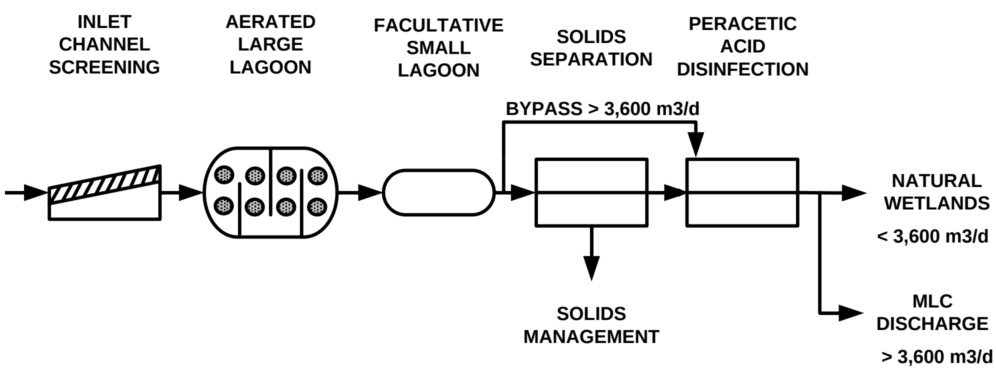


**Figure 3 – Option 1 – Phase 2A - Lagoon Upgrade to Meet MWR MEP Requirements**

MWR has an established reclaimed water quality criteria for wetlands flow augmentation under conditions whereby there is a low potential for public contact, referred to as a Moderate Exposure Potential reclaimed water quality - with a required BOD and TSS of less than or equal to 25 mg/L. This is the same water quality as achieved by Option 1 – Phase 1, but with a slightly higher quality disinfection standard. As the MEP water quality requirement does not require tertiary filtration to remove colloidal particles, it is less expensive to achieve than a GEP reclaimed water quality. An optional Reed Bed, if included, would also provide further treatment.

The release of reclaimed MEP water to the wetlands located to the north of the lagoons would augment the water flow through the natural wetlands and would result in an indirect discharge to Maple Lake Creek. This would enhance the habitat within the wetland area, and wetland plants would also benefit from the nutrients (phosphorus and nitrogen) in the effluent, resulting in reduced nutrient loading to Maple Lake Creek. The north wetlands are expected to provide a similar (duplicate) level of treatment to that being achieved currently through the wetland located downstream of the existing discharge into Maple Lake Creek and improves the water quality flowing in MLC upstream of the wetlands.

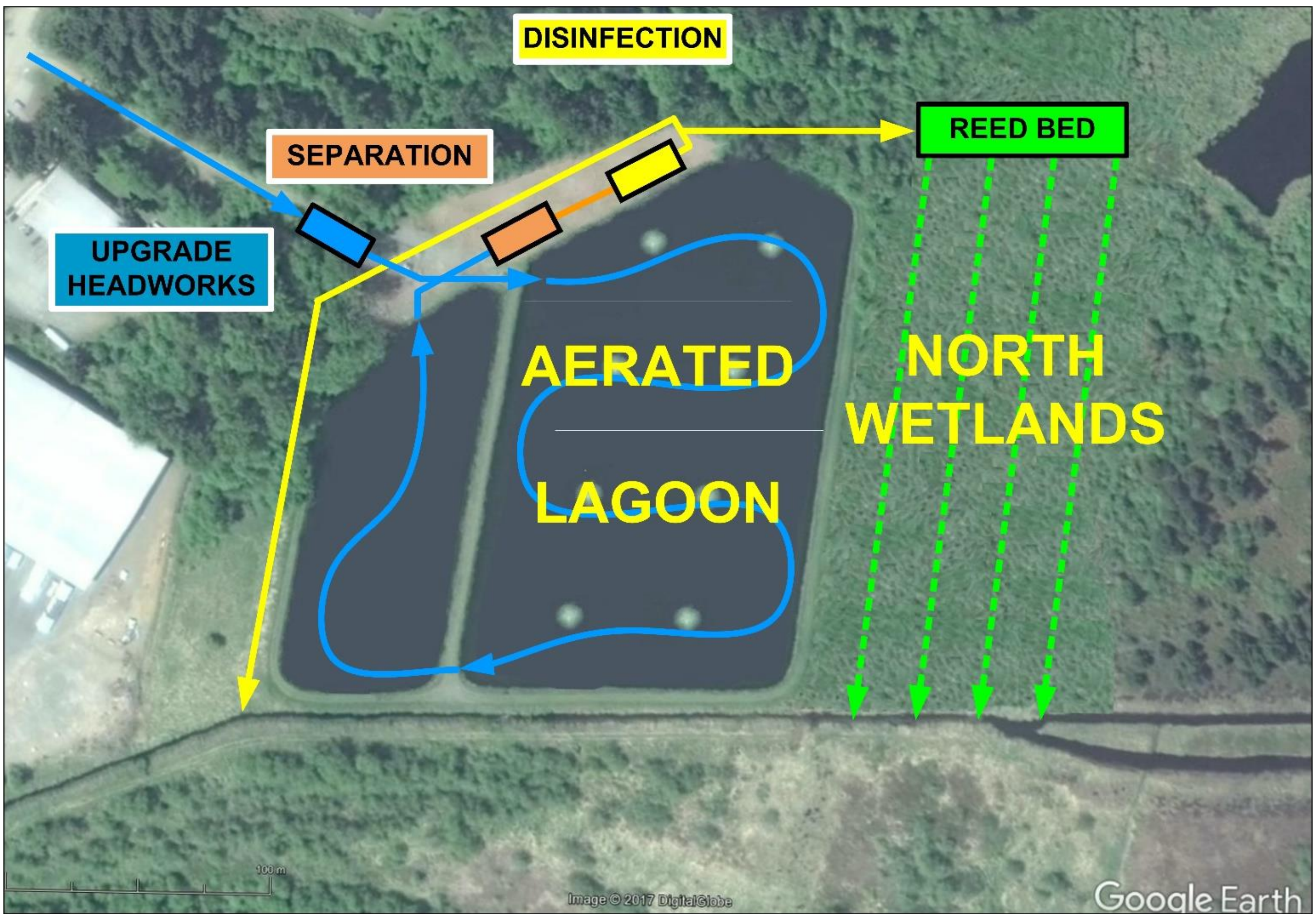


*Figure 4 Option 1 – Phase 2A - Lagoon Upgrade to Meet MWR MEP Water Quality Requirements with Optional Reed Bed and Augmented (Flow) to the North Wetlands*

The Ministry of Environment have established an ambient water quality objective for the Trent River of 0.005 mg/L. An advantage of the Phase 2A upgrade is that it is expected to significantly reduce the phosphorus concentration in the treated effluent to similar levels observed downstream of the wetlands in MLC. It is not possible to predict the degree of reduction or the long-term removal capacity within the north wetlands; however, if monitoring within MLC indicates a further reduction in phosphorus is required, chemical removal can be implemented at the solids separation stage. Given phosphorus concentrations in the Trent River, downstream of the confluence with MLC, as already close to the MoE phosphorus objective, there is a strong likelihood the 0.005 mg-P/L objective could be met by Phase 2A without chemical removal.

Lagoon Option 1 – Phase 2A could be constructed either as second phase to Option 1 – Phase 1, or as an initial construction project, if funding is available.

The following treatment is needed for Option 1 - Phase 2A, in addition to the works already done under Option 1 - Phase 1:

- Add a second influent screen, to meet the MWR redundancy requirements
- Add a second chemically enhanced separation unit, to meet the MWR redundancy requirements
- Add a pumping system for up to 3,600 $m^3$/day to transfer disinfected reclaimed water to the natural wetlands (and optional Reed Bed)
- Construct a subsurface distribution gallery or channel to disperse the reclaimed water to the north wetlands – with drainage and an indirect discharge to Maple Lake Creek.
- Optionally, construct the Reed Bed at the west end of the natural wetlands located along the north side of the new aerobic lagoon with discharge to a distribution channel into the natural wetlands. The Reed Bed is further discussed in TM #9, but has been included here as it is a convenient fit to build it at the same time as the wetlands distribution.

The Reed Bed and natural wetlands flow augmentation process layout is illustrated in Figure 4. There are many possibilities for how and where reclaimed water could be dispersed for beneficial augmentation purposes to the natural wetland. The process of installing the reclaimed water distribution system to the wetlands could also be used to create paths, elevated boardwalks, or public walking trails through the wetlands, increasing the amenity value.

### 2.5 <u>Option 1 – Phase 2B – Lagoon Upgrade to Meet MWR GEP Requirements</u>

Illustrated in Figures 5 and 6, Phase 2B is an alternative extension to the Phase 1 Lagoon Upgrade, and involves installing additional process equipment to meet the MWR registration requirements for Greater Exposure Potential (GEP) reclaimed water, with all of the water released to augment flows in Maple Lake Creek. The option could also direct baseflow to the north wetlands, and other reuse applications, if desired, and would enable Cumberland to continue to discharge to Maple Lake Creek. This Option considers that the current Discharge Permit would no longer be in effect and the discharge and treatment works would need to comply with the provincial MWR GEP water quality requirements. The process configuration for Option 1B is illustrated in Figure 5:

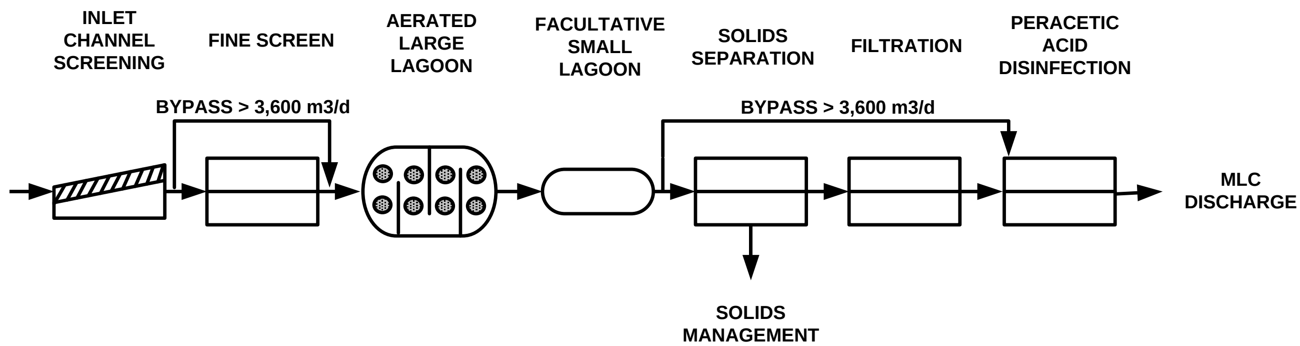


**Figure 5 – Option 1 - Phase 2B - Lagoon Upgrade to Meet MWR GEP Requirements**

Option 1 - Phase 2B includes full integration of all the scope defined the previous Option 1 – Phase 1 upgrade.

As noted earlier, an increase in the ADWF beyond 1,000 m3/d is expected to trigger a requirement for the Discharge Permit to be replaced with a Registered Discharge and compliance with the discharge requirements under current regulations, including additional requirements for effluent quality and equipment redundancy.

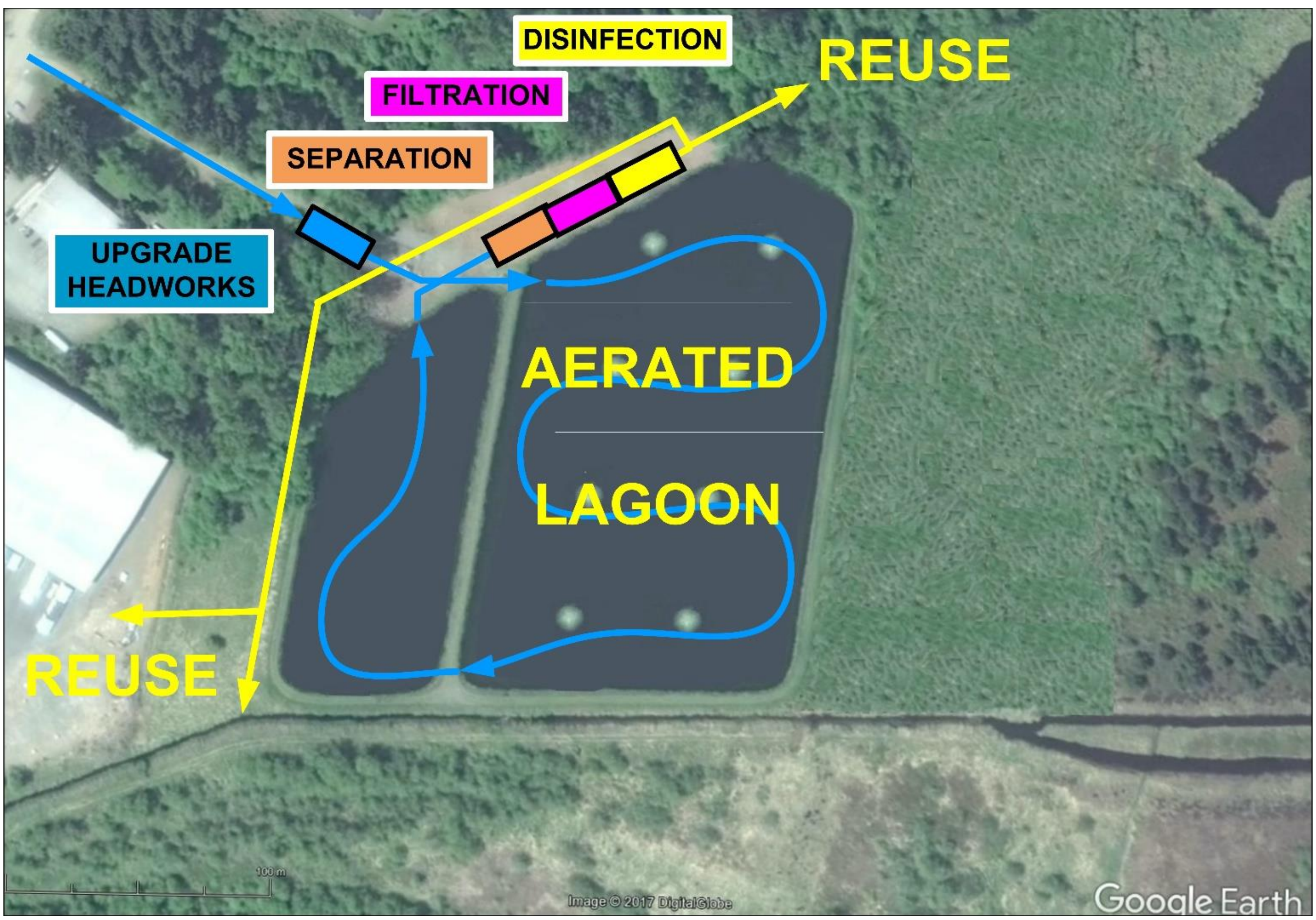


*Figure 6 Option 1 – Phase 2B - Lagoon Upgrade to Meet MWR GEP Water Quality Requirements for Stream and Wetlands Augmentation to MLC and Potential Other Water Reuse Applications*

With the Phase 2B upgrade, the treated effluent quality will meet the reclaimed water standard for Greater Exposure Potential. The following additional treatment will be needed in addition to the Phase 1 and possibly 2A works, as illustrated in Figure 5:

- Add a primary solids removal process to reduce influent BOD loading to the lagoons, to achieve effluent BOD concentrations of less than 10 mg/L;
- Operate the installed chemically enhanced solids/liquid separation unit to reduce TSS concentrations to less than 10 mg/L.;
- Add filtration to reduce the average turbidity to less than 2 NTU, with a maximum limit of 5 NTU.
- Achieve disinfection performance to reduce fecal coliform levels to median of < 1 CFU/100 mL, and maximum of 14 CFU/100 mL, with the disinfection system designed and sized to achieve the fecal coliform standard for summer and winter flows.

It should be noted that some of these works may not be required if the Phase 1 upgrade consistently meets the GEP criteria. If the system reduces the BOD and TSS to less than 10 mg/L and the average turbidity to less than 2 NTU, without filtration, then the disk filters would not be required and may be omitted.

Until any water reuse projects are developed, the upgraded works would continue to release all water to Maple Lake Creek (MLC) and/or the north wetlands. In planning for reuse, the environmental flow needs of Maple Lake Creek and the Trent River, particularly in summer, is expected to require a minimum critical discharge flow to maintain the health of the streams. This limits the ability to divert stream discharges for external reuse purposes during the summer months. An environmental assessment will be needed to assess the impact of reductions and determine discharge policies. This assessment is also a need of the Registration process.

# 3. OPTION 2 – BASEFLOW MECHANICAL TREATMENT

### 3.1 Option 2 – Baseflow Mechanical Treatment Process Description

As illustrated in Figures 7 and 8, Option 2 involves constructing a mechanical biological treatment process to treat up to 3,600 $m^3$/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 $m^3$/d would be diverted through the existing lagoon treatment system in its current configuration, prior to merging with the baseflow for disinfection and discharge to MLC.

This Option provides an “all-new” Cumberland treatment plant would meet the current MWR standards for treated water quality and equipment redundancy. As discussed in TM#1, a continued discharge to Maple Lake Creek under the MWR would require a reclaimed water standard meeting Greater Exposure Potential (GEP) conditions due to low dilution in the receiving environment. Mechanical treatment is well suited to producing a high-standard reclaimed water quality with a tightly controlled treatment process.

The selection of the baseflow threshold is based on the flow model developed in TM#4, Historical and Projected Flows and Loads. It is intended that the treatment plant will provide baseflow treatment for the projected population at the 20-year design horizon of 2038. The design ADWF is 1,800 $m^3$/day, and the MWR requires that treatment plants are sized to provide full treatment for flows up to 2 x ADWF, thus 3,600 $m^3$/day is selected as the baseflow threshold.

The historical flow records suggest that this flow threshold is exceeded from 40 to 60 days per year. However, during the dry summer period (May 1 to September 30), there has only been one exceedance in five years from 2013 to 2017, (which was September 30, 2013). Thus, a plant capacity of 3,600 $m^3$/d can be expected to provide full high-quality treatment of all the flows during the critical summer period.

*Table 2. Baseflow Mechanical Effluent Targets*

| Item | Criteria |
|---|---|
| Flow Threshold ($m^3$/day) | < 3,600 |
| Population capacity | 7,000 |
| BOD (mg/L) | ≤ 10 |
| TSS (mg/L) | ≤ 10 |
| Total Phosphorus (mg-P/L) | ≤ 1 |
| Orthophosphate (mg-P/L) | < 0.5 |
| Fecal Coliforms (CFU/100 mL) | < 1 (median)<br>≤ 14 (maximum) |
| Turbidity (NTU) | ≤2 (average)<br>≤ 5 (maximum) |
| Un-ionised ammonia (mg/L) | < 1.25 |

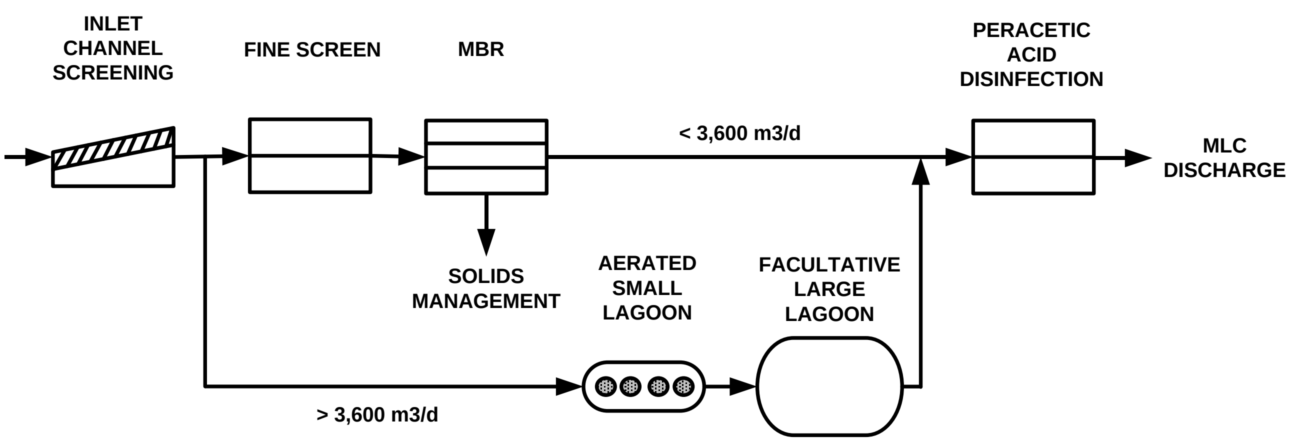


**Figure 7 – Option 2 – Baseflow Mechanical Treatment to Meet MWR GEP Requirements**

The advantage of Option 2 is that the plant can be optimised for the smaller range of flows. Pumps, pipes, blowers and holding basins can be smaller, and the limited flow range simplifies the hydraulic engineering, allowing use of some standardised process designs.

The main disadvantage is that the existing lagoons must be retained in operation, and there is a decrease in effluent quality as flows increase above the baseflow level. As the storm sewer separation program proceeds, future peak wet weather flows are expected to decrease, moving closer to the baseflow level. Further, as illustrated in Figure

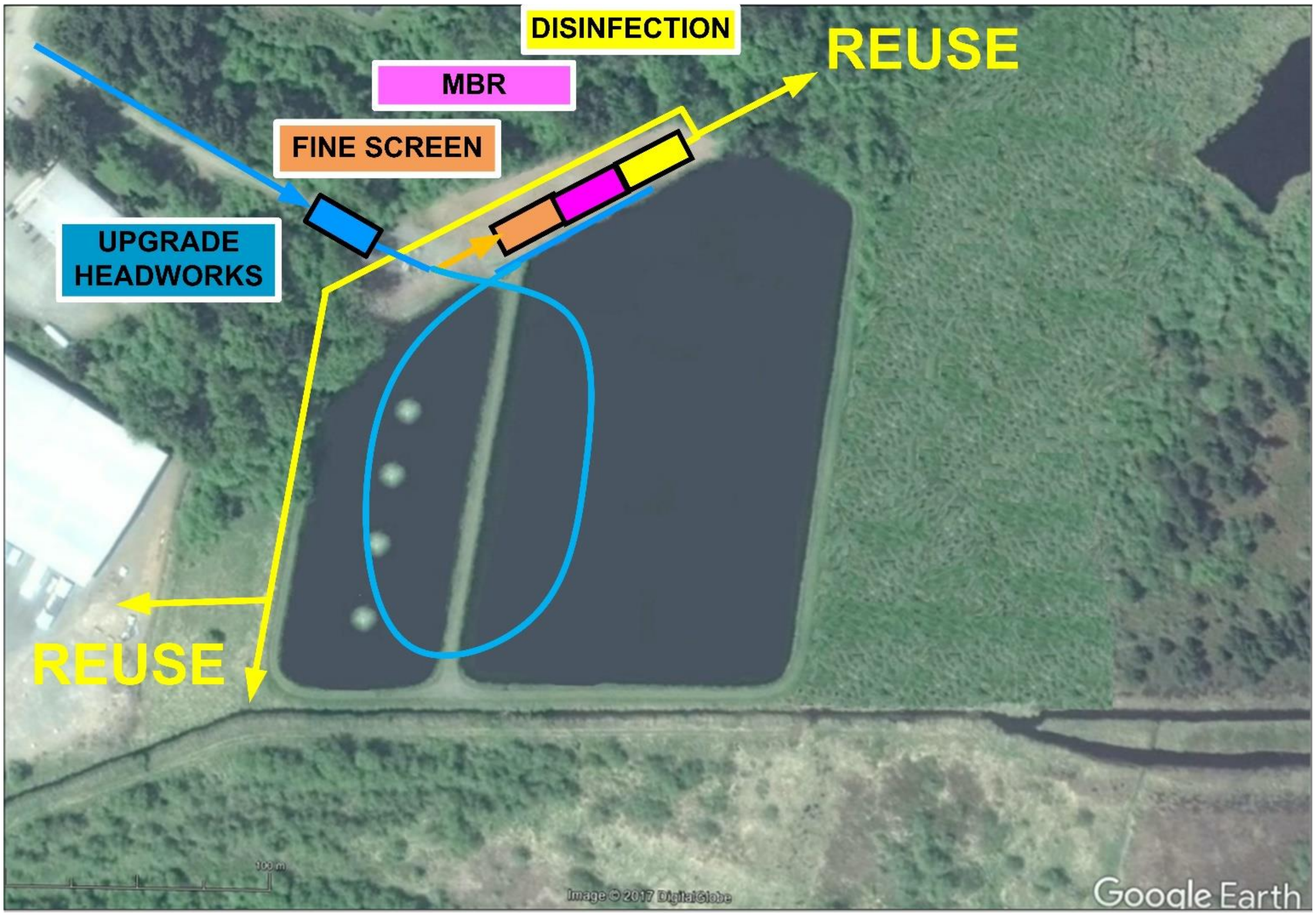


*Figure 8 Option 2 – Baseflow Mechanical Treatment to Meet MWR GEP Water Quality Requirements for Stream and Wetlands Augmentation to MLC and Potential Other Water Reuse Applications*

8, the flow pattern through the lagoons for excess stormwater flows is expected to be sub-optimal, with a high degree of hydraulic short circuiting unless additional funds are allocated for an Option 1 improvement to the lagoons.

### 3.1.1 Mechanical Process Requirements

There are a wide range of mechanical treatment processes that could be used for the baseflow concept. A "Membrane BioReactor" (MBR) treatment process has been selected as the design basis for this option. This process combines the BOD and TSS removal using an ultrafiltration membrane that allows water to filter through the membrane while retaining solids in the bioreactor. The accumulated solids in the bioreactor are removed (wasted) from the process, and then dewatered. The membranes are in large modular "cassettes" (as shown in Figure 8) that can be individually removed, cleaned and replaced as required. The membranes have a finite operating life, typically from 7-10 years, before they need replacement. The flow components for the proposed system are shown in Table 3.

*Figure 8. Membrane Cassettes from in a MBR system*

***Table 3 Baseflow Mechanical system components***

| **Unit Process** | **Flow range ($m^3$/day)** |
|---|---|
| Fine Screen | 14,400 |
| Grit Removal | 3,600 |
| Equalisation Tank | 3,600 |
| MBR system | 3,600 |
| Existing lagoons | 3,600-14,400 |
| Peracetic Acid Disinfection System | 14,400 |
| Biosolids dewatering by geotube | All biosolids produced |

Like most mechanical treatment plants, the MBR would produce a continuous output of biosolids, which need to be dewatered on site, and the filtrate water returned to the start of the process. As with the lagoon system the proposed dewatering process is by permeable synthetic filter bag (Geobag), which is further discussed in TM#10 Biosolids.

The MBR process combines the biological and separate separation (or filtration) stage in a single step. This provides a system that is very compact and can easily be enclosed for odour, noise control and aesthetic purposes. MBR's produce a high quality, filtered effluent and can be highly optimized when for designed for low variability flow. They are relatively complex systems, usually Class 4, and need an experienced operator. An MBR system has been in use at nearby Mt Washington Ski Resort for over 20 years, and at Ganges for about 15 years.

# 4. OPTION 2 – BASEFLOW MECHANICAL TREATMENT

### 4.1 Option 3 – Full Flow Mechanical Treatment Design Criteria

The “Full Flow” mechanical treatment approach is illustrated in Figures 9 and 10, and involves constructing a mechanical wastewater treatment process to provide high quality treatment for the entire flow range up to the Peak Wet Weather Flow of 14,400 m$^3$/day. As with the “Baseflow” concept, this would be an all new treatment plant that must meet all the requirements of the MWR, for quality, capacity and redundancy.

The treatment targets are based on the assumption that during the excess flow periods (> 2 x ADWF of 3,600 m$^3$/day), the turbidity target does not need to be met.

***Table 4. “Full Flow Mechanical” Effluent Targets***

| Item | Criteria |
|---|---|
| Tertiary Flow Threshold (m$^3$/day) | < 3,600 |
| Secondary Flow Threshold (m$^3$/day) | 14,400 |
| Population capacity | 7,000 |
| BOD (mg/L) | ≤ 10 |
| TSS (mg/L) | ≤ 10 |
| Total Phosphorus (mg-P/L) | ≤ 1 |
| Orthophosphate (mg-P/L) | < 0.5 |
| Fecal Coliforms (CFU/100 mL) | < 1 (median)<br>≤ 14 (maximum) |
| Turbidity (NTU) | ≤2 (average)<br>≤ 5 (maximum |
| Un-ionised ammonia (mg/L) | < 1.25 |

The Full Flow Mechanical treatment option (Figures 9 and 10) 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. Full description of this option can be found in the grant application documents as well as the RFP issued in 2016.

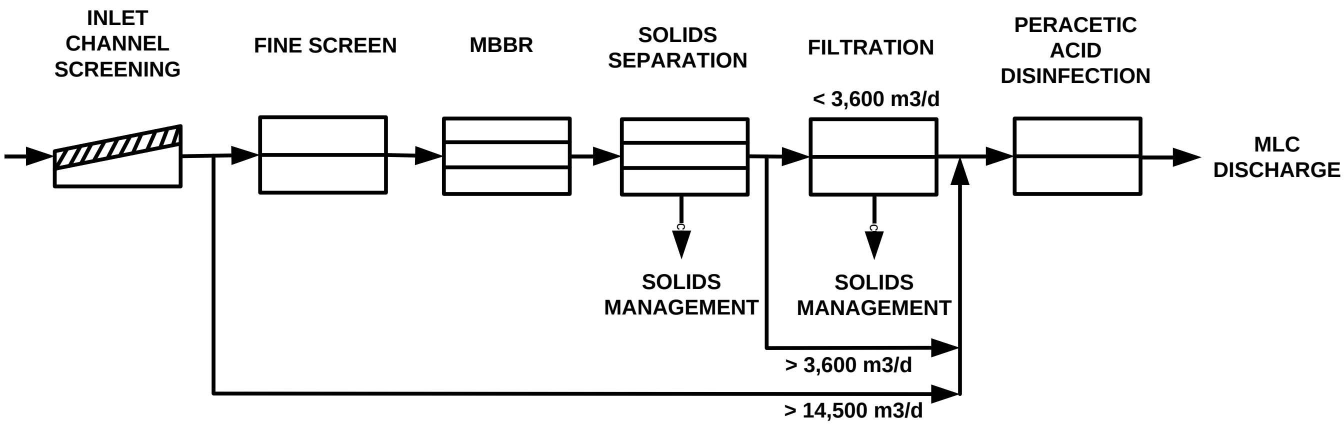


**Figure 9 – Option 3 – Full-Flow Mechanical Treatment to Meet MWR GEP Requirements**

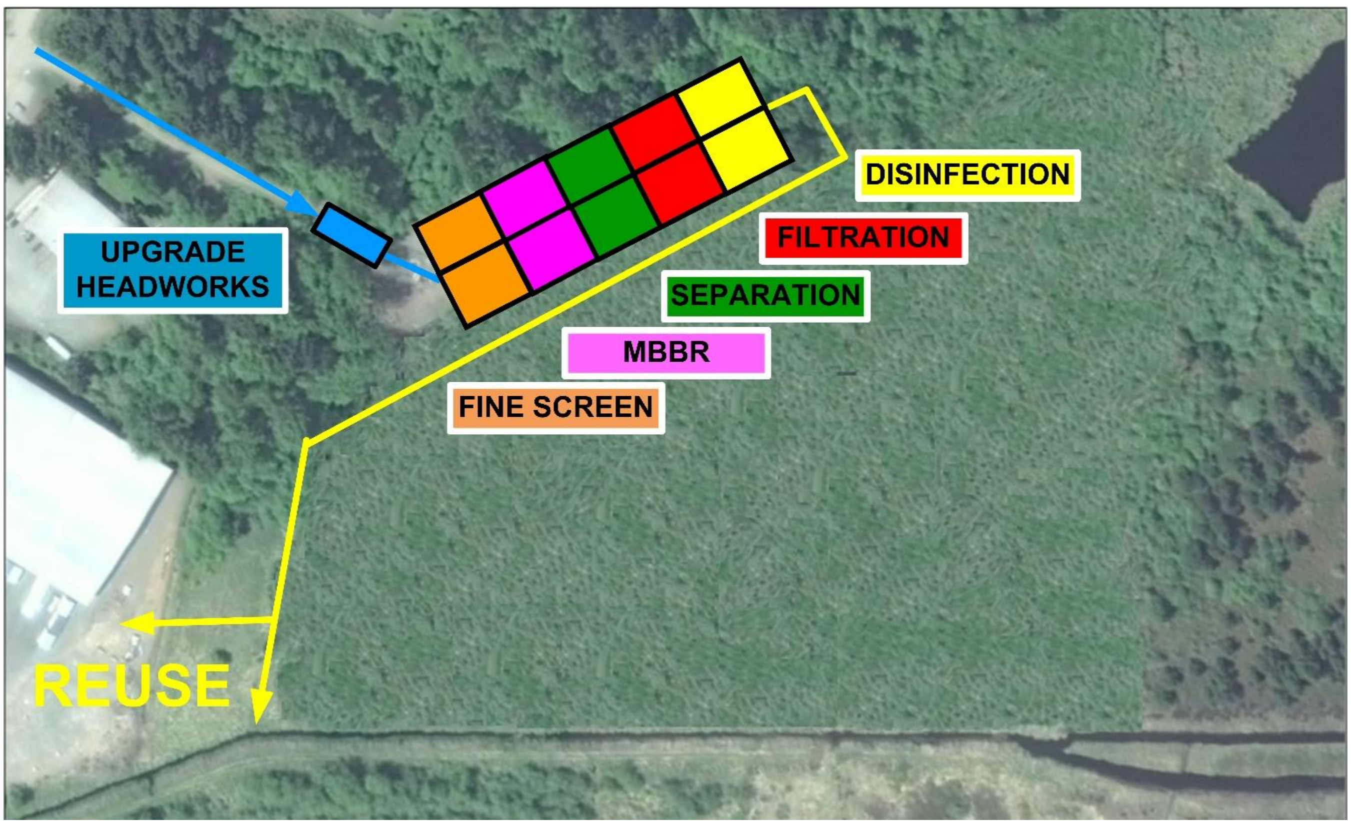


*Figure 10 Option 3 – "Full Flow" Mechanical Treatment to Meet MWR GEP Water Quality Requirements for Stream and Wetlands Augmentation to MLC and Potential Other Water Reuse Applications*

## 4.2 Mechanical Treatment Process Selection.

For the Full flow concept, the design flow range is from 1 to 8 x ADWF – an unusually high range to which some treatment processes are better suited than others. The Moving Bed Biofilm Reactor (MBBR) is a process that is particularly well suited to handling such large flow ranges.

Figure 10 shows a simplified representation of the process. Influent wastewater is treated in an aerated bioreactor containing polyethylene media. Aeration inside the tank keep the media in suspension as well as keep the tank in an aerobic state to maintain the health of the biofilm on the media. The media are kept in the tank by a screen inside the tank. The bacteria that are attached to the media eventually slough-off to be separated from the liquid through a clarifier.

Conventional clarifiers are not well suited to flow surges, such as the Cumberland design flow peaking factor of 8:1, or must be greatly oversized to accommodate them. For the "full flow" concept, the clarifier is replaced with a chemically enhanced solids separation system, as is proposed for the lagoon upgrade options. These systems use chemical conditioning to coagulate dissolve constituents and flocculate (clump) the fine suspended solids, including algae, and then separate them from the water. There are numerous engineered configurations for the separation process of these separation systems.

These units are specifically designed in providing consistent solids removal over a wide range of flows and offer superior performance over gravity settling for rapid changes in influent quality expected with the high inflow and infiltration.

For assurance on meeting the low turbidity required for GEP reuse water, a final filtration process is required. A media "disc filter" is the recommended option. These are specifically designed for final filtration of wastewater, and are higher performance than sand filters and less complex than membranes.

The treatment process is completed by Peracetic Acid disinfection prior to discharge to Maple Lake Creek.

*Table 5. Full Flow Mechanical system components*

| Unit Process | Flow range ($m^3$/day) |
|---|---|
| Fine Screen | 14,400 |
| Grit Removal | 14,400 |
| MBBR system | 14,400 |
| Liquid/Solid Separation | 14,400 |
| Disk Filtration | 3,600 |
| Peracetic Acid Disinfection System | 14,400 |
| Biosolids dewatering by geotube | All biosolids produced |

Like most mechanical treatment plants, the MBBR would produce a continuous output of biosolids, which need to be dewatered on site, and the filtrate water returned to the start of the process. As with the lagoon system the proposed dewatering process is by "geotube", which is further discussed in TM#10 Biosolids.

The MBBR system is ideal for maintaining high effluent quality while handling the large flow variations that are characteristic of the Cumberland wastewater system. It will be a relatively complex system, being either Class 3 or 4, and will require an experienced operator.

With the Full Flow Mechanical system, the lagoons are decommissioned, and the entire 4ha land area can be repurposed for other community uses, e.g. parkland. Regaining the land is the main benefit of the full Flow mechanical system over the Baseflow mechanical, where the lagoons must be retained.

# 5. OPTION 2 – PHASED UPGRADE

A key consideration in the development of the treatment options was the ability to do a "phased implementation"- this is Option 1, Phase 1 - Lagoon Upgrade for Permit Compliance. It allows for a lower cost initial project to meet the immediate regulatory needs. But this is not an endpoint Option, as a second phase is required to;

- Increase population capacity from 5,000 to 7,000 people
- Meet MWR effluent quality requirements if Maple Lake Creek is the primary discharge
- Meet MWR requirements for process equipment redundancy

And the second phase would be to complete as one of Option 1 – Phase 2A, Option 1 – Phase 2B, Option 2 or Option 3.

As designed, each Option can be implemented as either a single, or two-phased implementation. While a two-phase approach allows deferring some works and cost to the future, it also increases the total cost over a one-phase execution, as two projects are being done, and there are additional costs incurred for:

- Construction with more sharing of trade resources
- Freight
- Storage
- Contractor Overhead, including mobilisation and demobilisation
- Supervision and Safety
- Engineering
- Owners costs and project management
- Material Contingency

There is approximately 10% increase in these "indirect" costs for implementing a two-phase execution.

An additional factor is that some of the Phase 1 works become redundant for some of the Options, when completed as a second phase

Option 1 Phase 1, Phase 2A or Phase 2B align well for a phased approach – there is no redundancy of any Option 1 - Phase 1 works.

Option 2 can also be completed after Option 1 - Phase 1. The upgrades to screening, disinfection and solids dewatering are all the same for Option 2. The solids separation unit of Option 1 - Phase 1 can be re-purposed to primary treatment before the mechanical process. The lagoon reconfiguration of Option 1 - Phase 1 is not required for Option 2, but if Option 1 - Phase 1 has been completed, then the reconfigured lagoons will serve Option 2, and provide slightly better treatment of excess flows. While the MBR process can be implemented after Phase 1, other mechanical treatment systems (such as MBBR) can also be considered when Option 2 is implemented as a second phase.

Option 3 can also be completed after Option 1 - Phase 1 (the initial upgraded lagoon for Permit compliance). The upgrades to screening, disinfection and solids dewatering are all the same for Option 3. The solids separation unit of Phase 1 becomes redundant, as it is replaced by two larger units, but can be retained as a standby or baseflow unit. The lagoon reconfiguration of Option 1 - Phase 1 is not required for Option 3, so this work also becomes redundant.

Overall, the phased approach provides flexibility and a more affordable first project, but at an increase in total capital cost. These costs are discussed in Technical Memo 7B-Rev2.