Liquid Waste Management Plan
Technical Memorandum

LWMP Technical Memorandum #6

TO: Wastewater Advisory Committee

SUBJECT: Discharge Options

DATE: October 30, 2017

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1.0 BACKGROUND

The Village of Cumberland (VoC) currently has a Discharge Permit to discharge disinfected secondary effluent, with phosphorus removed to less than 1 mg-P/L, from the wastewater treatment lagoons to Maple Lake Creek, which drains to the Trent River, and eventually discharges into Baynes Sound. There are limited possible alternatives to discharging into Maple Lake Creek. For example, conveying treated wastewater effluent to Comox Lake was considered, and may be technically possible, but the costs combined with the use of Comox Lake as a potable water supply makes this option unfeasible.

The Discharge Permit has been in place for over 50 years and contributes water to the environment along that drainage course that otherwise would essentially be dry during the summer months. Consequently, the consideration of discharge options for treated effluent is logically limited to the manner in which a continued release to Maple Lake Creek and the watershed can be maintained.

In September 2016, the Wastewater Advisory committee selected the following short-list of effluent disposal for further study, as follows;

Winter (Oct-Apr);

1. Maple Lake Creek

Summer (May-Sep)

1. Maple Lake Creek
2. Seasonal Storage – store summer effluent and release into MLC during winter.
    a. Storage Wetland to be constructed on north side of lagoons
    b. Storage Reservoir in natural depression north of Teal Lake (2km NE of lagoons)

During the environmental study work in 2017, a new option, not previously considered, was developed – using the treated water for year-round “discharge to the natural wetlands” to the north side of the lagoons.

OPTION 1. DISCHARGE TO MAPLE LAKE CREEK

Maple Lake Creek is the current discharge location, and has been since the inception of the lagoons in 1968. It is the “default” discharge location, and given the large flow volumes to be handled in winter, is the only practicable location for winter discharge.

As noted in Technical Memo #1, the water quality requirements for a continued discharge to Maple Lake Creek and the Trent River are expected to change as a result of the community's anticipated increase in wastewater flow. While the Ministry of Environment may be wiling to approve a minor 10 percent increase (by policy and precedent deemed to be considered a minor amendment) to the Discharge Permit flow of 910 m^3/d, potentially increasing the authorized Discharge Permit flow to 1,000 m^3/d, once this is exceeded, or Cumberland chooses to make provisions for reclaimed water use, the Village will need to meet the requirements of the MWR. Because the minimum available dilution in Maple Lake Creek is much less than the 10:1 dilution allowed under the MWR for an effluent discharge, the only way Cumberland can continue to release treated effluent to Maple Lake Creek is if the water quality meets the Greater Exposure Potential reclaimed water quality standard. Additionally, the current provincial 0.005 mg-P/L in-stream phosphorus objective for the Trent River will also have to be met.

Table 1 Effluent Quality Targets for discharge to Maple Lake Creek

Item	Current Permit	MWR "GEP"
ADWF (m^3/day)	910, (may be increased to 1000)	1,800
pH	NR	6.5 - 9
BOD (mg/L)	≤ 30 (max) ≤ 25 (avg – WSER)	≤ 10
TSS (mg/L)	≤ 30 (max) ≤ 25 (avg – WSER)	≤ 10
Total Phosphorus (mg-P/L)	≤ 1	≤ 1
Orthophosphate (mg-P/L)	NR	≤ 0.5
Fecal Coliforms (CFU/100 mL)	≤ 200 (max)	< 1 (median) ≤ 14 (maximum)
Turbidity (NTU)	NR	≤ 2 (average) ≤ 5 (max)
Un-ionised ammonia (mg-N/L)	< 1.25	< 1.25
Trent River In-Stream Phosphorus Objective (May to Sep) (mg-P/L)		< 0.005 (average) < 0.01 (max)

The flow measuring program of summer 2017 confirmed that the dilution ratio at the point of discharge from the lagoons is near zero during dry summer conditions. Several field measurements were made on July 31. Even though the temporary weir measurements may be +/-20 %, they confirm what had been already been observed – there is virtually no dilution of the discharge from the lagoons into Maple lake Creek or the Trent River.

The negligible dilution in MLC suggest that a withdrawal of effluent from MLC would cause the creek to be dry in the summer, and halve the flow of the lower Trent. Consequently, a reduction in the current level of discharge to MLC during the summer would be expected to have a negative impact on the aquatic and riparian life of both streams.

Table 2 Targets for discharge to Maple Lake Creek (July 31, 2017)

Location	Flow (m^3/d)	Measurement
MLC upstream of lagoons	Effectively zero	Visual observation
Lagoon discharge	800	Lagoon Measuring weir
End of MLC wetland reach (1 km upstream of Trent)	660	Temporary measuring weir
Trent River at Hwy 19 (1 km upstream of MLC)	660	Temporary measuring weir
Estimated flow in Trent at MLC confluence	1,320	Visual observation

For winter conditions there is greater dilution in MLC and large dilutions in the Trent, and environmental flows are not expected to be an issue.

The primary reason for considering discharge location alternatives to MLC was to address the Ministry's concerns for phosphorus loading to the Trent River during the summer months, and meet the Ministry's new in-stream phosphorus concentration objective for the Trent River of 0.005 mg-P/L.

As discussed in TM#4, and illustrated in Table 3, the natural wetlands in Maple Lake Creek are very effective at removing the effluent phosphorus. The wetlands downstream of the lagoon discharge are removing approximately 97% of the phosphorus in the lagoon – performance that cannot reliably be achieved in any normal wastewater treatment process. The proposed treatment upgrades to meet the Permit and MWR phosphorus requirements of 1 mg-P/L will likely result in an average effluent total phosphorus concentration of 0.5 mg-P/L, or a 6.5 mg-P/L reduction in effluent total phosphorus, reducing the total phosphorus load to Maple Lake Creek from 6.12 kg-P/day to 0.45 kg-P/day, a reduction of 5.67 kg-P/d; whereas the wetland are currently taking up 5.94 kg-P/d. The decrease in phosphorus load to the natural wetlands along Maple Lake Creek is expected the put the wetlands into a growth condition that will scavenge available phosphorus, and consequently it is expected the total phosphorus concentration at the end of MLC will be near the detection limit, and in-stream criteria of 0.005mg/L. While it is expected that a higher effluent total phosphorus concentration would result in similar in-stream total phosphorus conditions in Maple Lake Creek, the existing Discharge Permit established in 1997 requires an effluent total phosphorus concentration of less than 1 mg-P/L be met.

Table 3 Phosphorus removal along Maple Lake Creek and Trent River

Location	Avg. Total P (mg-P/L)	TP Load (kg-P/day)	Reduction
MLC upstream of lagoons		0	
Lagoon discharge	6.8	6.12	Effluent
End of MLC	0.2	0.18	97%
Trent River 100m upstream of MLC)	< 0.005	< 0.0045	Trent Baseline
Trent 100m downstream of MLC	0.035	0.063	99%

Key points about discharge to Maple Lake Creek;

- It is the only practical discharge location for winter;
- The current summer discharge is effectively 100% of the flow in Maple Lake Creek;
- It is environmentally desirable to maintain some or all of the current summer flow level in Maple Lake Creek;
- The wetlands downstream of the lagoon discharge into Maple Lake Creek are removing 97% of the total phosphorus loading to the Creek by about 5.7 kg-P/day;
- Treatment to reduce the total phosphorus concentration from 6.8 mg-P/L to an expected 0.5 mg-P/L will reduce the phosphorus loading to MLC to about 0.45 kg-P/day; whereas the current phosphorus uptake is about 5.9 kg-P/day. The deficit in phosphorus is expected to drop the phosphors concentration at the end of MLC to less than the provincial objective of 0.005 mg-P/L;
- The instream objective of 0.005 mg-P/L within the Trent River is expected to be met;
- The natural wetlands on Maple Lake Creek are a real-world example of an "eco-asset", performing a valuable function for Cumberland.
- As Cumberland grows, so too will the summer flow of treated water to Maple Lake Creek, eventually doubling from its current level. With improved treatment quality, this increase in flow will be beneficial to the downstream aquatic life in MLC and the Trent in summer droughts. It is a rare case of where urban growth will create a direct benefit to a local ecosystem!

2.0 OPTION 2. SEASONAL STORAGE

The motivation for the storage options is a different way to meet the summer instream phosphorus objective of 0.005 mg-P/L in the Trent River. Instead of reducing the effluent phosphorus concentration, all of the summer discharge would be stored, to be released during the winter when there is no instream phosphorus objective in the Trent River, and the dilution levels are much greater.

There were two specific storage options developed in 2016;

a. Storage Wetland to be constructed on north side of lagoons
b. Storage Reservoir in natural depression north of Teal Lake (2km NE of lagoons)

Option 2A: Storage "Wetland"

The Storage Wetland involves construction of a new pond on the wetland area north of the lagoons and east of Maple Lake Creek. It would occupy the same area the previous 2006 wetland concept, but the "pond" would be 2-3m deep to create storage volume, rather than a shallow "treatment" wetland. Construction of this storage would involve extensive earthworks to remove the peat and create the earthen berms that would define the pond. The concept arrangement is shown in Figure 1.

The storage would be landscaped and an island, bird nesting sites and other vegetation and habitat features, this being the "wetland" part of the concept.

If the stored water meets the quality requirements for "Greater Exposure Potential", the area can publicly accessible and does not need to be fenced. The perimeter could become public walking trails making it an attractive public amenity. If the water only meets the requirements for Moderate Exposure Potential, public access would need to be discouraged, at a minimum, or possibly restricted.

There would be some environmental assessment and approvals required to implement this concept.

The Storage Wetland is entirely on Village of Cumberland owned land.

Figure 1 Option 2A - Storage Wetland Concept

The cost to build the wetland ponds for the 2006 wetland concept was estimated in the order of $5M. Even though this concept is half the area, the pond is twice the depth, and the berms would be twice as high. A detailed cost evaluation has not been done, but it is unlikely that this reservoir would be built for any less than the $5M estimate. From 2006.

Option 2B: Storage "Reservoir"

The Storage Reservoir would be built in natural depression near Teal Lake, and requires a pumping station at the lagoons and a 2.3km connecting pipeline. The highest elevation of the pipe is about 40m above the lagoons, so this is a moderate pumping head. This arrangement is shown in Figure 2. The natural depression is about 5m deep, and some earthworks would be required to make a 5-7m high dam wall along the south-east side of the reservoir area. The depth of water in at the deepest point would be 10m when full and about 5m when "empty".

The storage could be habitat enhanced in a similar way to the wetland, but this is not an essential component to the Storage Reservoir concept.

If the stored water meets the quality requirements for "Greater Exposure Potential", the area can publicly accessible and does not need to be fenced. The perimeter could become public walking trails making it an attractive public amenity. If the water only meets the requirements for "Moderate Exposure Potential", public access would need to be discouraged, at a minimum, or possibly restricted.

There would be some environmental assessment and approvals required to implement this concept.

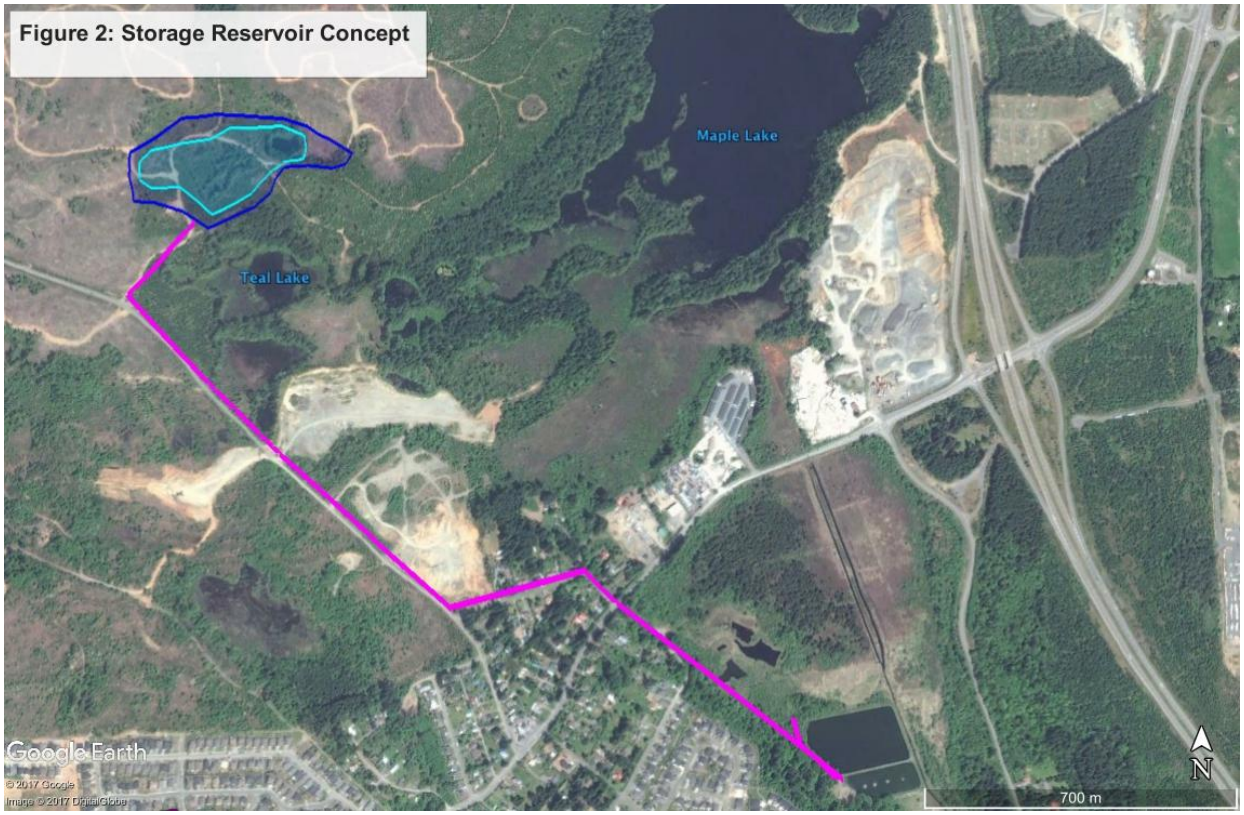

Figure 2 Option 2B - Storage Reservoir Concept

The Storage Reservoir is entirely on and owned by Comox Timber Ltd, so a possession agreement would need to be negotiated.

The pipeline right of way is predominantly on Village of Cumberland roads and lands.

A detailed analysis of construction costs has not been made, but a “concept budget” is illustrated in Table 1.

Table 1 Option 2B - Storage Reservoir Concept Budget

Reservoir Earthworks	$1.0M
2.3km pipeline, 12 “ HDPE, $500/metre laid	$1.15M
Pump station $0.15M	$0.15M
Subtotal $2.35M	$2.3M
Engineering @ 15% $	$0.35M
Land Acquisition Cost	Unknown
Contingency @50% (class D estimate)	$1.32M
Total	**$4.0M**

Analysis of Storage Options

For the seasonal storage to be feasible, it must be environmentally acceptable to divert all of the treated wastewater from Maple Lake Creek to storage. Had the proposed Comox Valley Regional District "South Sewer Project" proceeded, it would have would have resulted in 100% of the Cumberland lagoon discharge being removed from the Maple Lake Creek catchment during the summer, and would have resulted in the near elimination of summer flows in Maple Lake Creek and an estimated halving of the summer flows in the Trent River with an expected consequential increase in ambient stream water temperature, and a concurrent reduction in dissolved oxygen within the Trent River during the summer as a consequence.

One of the objectives of the summer 2017 environmental monitoring program was to assess the streamflow in Maple Lake Creek and the Trent, and the potential impact of its removal.

The streamflows presented in section 2.0 above confirmed that there was:

- Effectively zero dilution of effluent in MLC at the lagoon discharge location;
- Some loss of streamflow along the length of MLC; and
- Approximately a 1:1 dilution with the Trent River at the confluence with MLC.

To do a complete withdrawal of the effluent flows under these conditions is expected to have a detrimental impact on the environmental and habitat conditions along Maple Lake Creek and within the Trent River. A detailed habitat study was not conducted, but it is expected that a study would conclude that stream augmentation is needed and that more streamflow, not less, is needed, and that complete cessation of the Cumberland lagoon discharge would have a greater negative impact than the effects of the current phosphorus contributions from the Cumberland lagoons taking into consideration the phosphorus uptake due to the Maple Lake Creek wetlands.

To make the storage option work, without adversely affecting summer water flows in Maple Lake Creek and the Trent River, it will be necessary to offset the loss of effluent flows to the creek by substituting an equivalent flow of fresh water.

Conceptually, this would involve releasing a volume of potable water equivalent to the wastewater generated by Cumberland, effectively doubling the domestic water demand during the summer - defeating all the metering and other water conservation initiatives, and depriving Cumberland of water capacity for population growth.

An alternative was considered, involving the construction of storage basins to collect stormwater runoff during the winter months, and release the stored water proportionately with the amount of wastewater effluent being diverted during the summer months. This would require building separate storage basins to enable stored stormwater to be released while treated wastewater effluent was stored, likely requiring two separate piping systems and (possibly) two pumping systems. A Provincial water licence might also be required if the stored freshwater water was diverted from a stream. Even without doing any detailed analysis, it is obvious that this "dual storage" system has doubled in cost and become unexpectedly complex.

A third option could be to create a single storage basin that would be used to store water during the winter, and then displace the stored water with treated wastewater during the summer, within the same common basin. Initially the release would be predominantly stored rainwater, and would gradually become dilute wastewater over the summer, depending on how or whether the storage basin was partitioned. The concentrations of phosphorus in the storage would gradually increase over the summer, depending on the degree of mixing occurring. This concept could quickly defeat the objective of "removing all the phosphorus by removing all the water" unless the storage was large.

Ultimately, the original rationale for the storage, to remove the phosphorus, has to be questioned in the light of the phosphorus removal performance of Maple Lake Creek. With MLC removing 97% of the phosphorus, the incremental benefit of removing 100% of the phosphorus through storage, is questionable – achieving a very small benefit at a very large cost.

Key points about storage options;

- The cost for the either of the single storage options is expected to be at least $4M
- With zero dilution in Maple Lake Creek, doing 100% withdrawal of summertime effluent, without any flow replacement, is environmentally unacceptable.
- Storing winter freshwater for flow replacement effectively doubles the cost and complexity of the storage system.
- 97% of the effluent phosphorus is being removed by the natural wetlands in Maple Lake Creek;
- ***Based on the above, the recommendation of the Technical Consultant is that the storage options are neither practical nor needed, and that these options not considered further.***

3.0 DISCHARGE TO NATURAL WETLANDS

A continued discharge to the Maple Lake Creek catchment and the Trent River is considered to be a necessary requirement due to the negative impact that would be caused by removing the discharge and the resulting extremely low flows in the two streams. While the current Discharge Permit authorizes a continued release of secondary treated effluent, a requirement to register the discharge and comply with the current Municipal Wastewater Regulation (MWR) would result in a need to upgrade the discharge water quality to be able to continue to discharge to MLC and the Trent River as a result of the low dilution (less than 10:1) during the summer months.

The water quality requirements under the MWR differ, depending on how the water is discharged to MLC. Because the dilutions in MLC are less than 10:1 during the summer, a direct discharge into MLC would require the water to meet Greater Exposure Potential reclaimed wastewater water quality conditions; whereas an indirect discharge to MLC through the wetlands to the north of the lagoons is expected to only require the water to meet Moderate Exposure Potential reclaimed wastewater water quality conditions. The reason for the difference is that a direct discharge to MLC has a greater potential for public contact than a subsurface discharge to the wetlands that can be implemented in manner that the public would not be expected to come into direct contact with the discharged water.

The Moderate Exposure Potential (MEP) water quality criteria is as follows:

- BOD5 $\leq$ 25 mg/L (maximum)
- TSS $\leq$ 25 mg/L (maximum)
- Fecal coliform $\leq$ 100 CFU/100 mL (median) and $\leq$ 400 CFU/100 mL (maximum)
- pH 6.5 - 9

While passage of the reclaimed wastewater through the wetlands is expected to result in a significant reduction in the phosphorus concentration due to plant uptake and mineralization, some chemical phosphorus treatment may be required prior to release to the wetlands.

The strategy would be to disperse MEP reclaimed water in a subsurface manner to the natural wetlands, allowing the water to flow through the wetlands and drain into Maple Lake Creek on a year-round basis, while discharging treated effluent flows greater than 2 x ADWF, and that exceed the wetlands hydraulic capacity, directly to Maple Lake Creek during the winter months.

The reclaimed water that is released to the wetlands will be subjected to passive treatment as it passes through the wetlands and eventually drains into Maple Lake Creek, including:

- residual BOD and TSS concentrations will be reduced as a result of bacterial treatment through the soil;
- ammonia will be nitrified to nitrate, and phosphorus and nitrogen concentrations will be reduced as a result of plant uptake and phosphorus mineralization.

The use of reclaimed wastewater to augment flows in the wetlands are also expected to enhance the wildlife habitat within the wetlands.

A hydrological assessment should be carried out to verify the ability of the wetlands to accept 3,600 m^3/day, representing 2 x ADWF. As algae is expected to exceed the maximum TSS criteria of 25 mg/L during the summer, some form of solids/liquid separation will likely be required following lagoon treatment prior to disinfection and release to the wetland. With the noted improvements to the lagoon system to meet the conditions of the current Discharge Permit, the MEP reclaimed wastewater water quality conditions are also expected to be met.

The wetland discharge can maintain free water ponds and soil moisture during extended summers, enhancing wildlife habitat and tree growth. A project of distributing water to the wetlands area would also open the way for a network of walking paths to be built in the area, increasing the public amenity of the wetlands. This was a desirable feature of the treatment wetland concept of 2005-2008, and could be a feature of a wetland augmentation. In effect, there is no need to construct the wetland as proposed in 2005, the water can just be taken to the wetland that is already there.

Additionally, a habitat enhancement program could be undertaken to remove some invasive plant species and plant native forest species, to be irrigated with the reclaimed water. With careful design implementation and maintenance, a highly functional habitat could be created on this abandoned farmland.

A good example of this concept is the award-winning Maleny Treatment Wetland, in Queensland, Australia. This involved a 13.8 ha forest planting, on former farmland, irrigated by subsurface drip effluent, and a 3ha constructed treatment wetland. All the effluent from the treatment plant of this town of 3500 people goes through the forest and then the wetland before reaching the local creek, which runs into a drinking water storage reservoir. Even though the reclaimed water is already of very high quality, significant polishing and nutrient removal happens as the water moves through the forest and wetland area. The project was a joint initiative with a local conservation group who did the tree plantings and maintenance, and is widely regarded as a success, winning a UN Environmental award in 2015. For more information go to the link at http://waterandcarbon.com.au/wp-content/uploads/2016/02/WCG-Case-Study-Maleny.pdf

4.0 SUMMARY

In 2016, the LWMP committee identified that finding a suitable discharge location was a major issue of the Cumberland LWMP. This was driven mainly by a desire to avoid the 0.005 mg-P/L summertime in-stream phosphorus criteria of the Trent River, what was thought to be impossible or very expensive to achieve.

The environmental monitoring program of 2017 verified that not only is Maple Lake Creek removing 97 % of the phosphorus, but also that sending the all water to another watershed, or diverting the discharge to storage during the dry summer months, would effectively dry up the creek during the summer, with associated environmental consequences.

A modest effort to reduce treated wastewater total phosphorus concentration to less than 1 mg-P/L is expected to have a much greater impact on achieving the provincial instream phosphorus objective set for the Trent River of less than 0.005 mg-P/L. It is expected that in targeting a treated water phosphorus concentration of 1 mg-P/L, that an average concentration of 0.5 mg-P/L can reliably be achieved. This represents an overall reduction of about 5.7 kg-P/day, whereas the natural wetlands downstream of the lagoon discharge to Maple Lake Creek is currently removing 5.9 kg-P/d. The decrease in phosphorus load to the natural wetlands along Maple Lake Creek is expected the put the wetlands into a growth condition that will scavenge available phosphorus, and consequently it is expected the total phosphorus concentration at the end of MLC will be near the detection limit, and the Ministry of Environment in-stream objective of 0.005 mg-P/L is expected to be met in both MLC and the Trent River. While it is expected that a higher effluent total phosphorus concentration would result in similar in-stream total phosphorus conditions in Maple Lake Creek, the existing Discharge Permit established in 1997 requires an effluent total phosphorus concentration of less than 1 mg-P/L be met.

Consequently, the philosophy has changed from one of removing the water to one of retaining the water, to maintain the summertime flow into Maple Lake Creek.