Strathroy WWTP Upgrades

Aerated Lagoon Upgrade Report

FINAL

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Prepared for:

STRATHROY-CARADOC

URBAN OPPORTUNITY – RURAL HOSPITALITY

arva

Strathroy WWTP Upgrades – Aerated Lagoon Upgrade Report

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1.0 PROJECT BACKGROUND AND OBJECTIVES

The existing Strathroy Wastewater Treatment Plant (WWTP) has a rated capacity of 10,000 m^3/day and currently operates at approximately 50% of the rated capacity. The plant is an aerated lagoon based on the extended aeration process and has a single cell with no means to isolate or drain any section of the lagoon to allow for maintenance and cleaning. Inability to properly complete maintenance has led to the accumulation of solids on the lagoon slopes and bottom. This accumulation is resulting in accelerated release of soluble $cBOD_5$ during spring and summer and is a contributing factor to the recent effluent $cBOD_5$ exceedances. To allow for long-term maintenance and cleaning, the Municipality requires a redundant system which would allow for the lagoon to taken offline for an extended period. The performance of the Plant will continue to deteriorate if upgrades are not completed and charges from the Ministry of the Environment, Conservation, and Parks (MECP) will be likely.

In pursuant of this, The Municipality of Strathroy-Caradoc has retained R.V. Anderson Associates Limited (RVA) to propose solutions as part of the Strathroy WWTP Upgrades Project.

The objectives of this technical memorandum are:

- To review the existing headworks building and the plant hydraulics issues and propose upgrade alternatives.
- To propose and review the following three options to upgrade the biological treatment and provide redundancy to the existing aerated lagoon. The options are:

- **Option One** – Add extended aeration tanks sized for the current average day flow (ADF) of 5,500 m^3/d, with a plan to convert the WWTP to a conventional activated sludge (CAS) system with rated capacity of 10,000 m^3/d in the future; or.
- **Option Two** – Add concrete extended aeration tanks for the plant rated capacity of 10,000 m^3/d.
- **Option Three** – Utilize the existing south lagoon to build one new aerated lagoon for the plant rated capacity of 10,000 m^3/day.

2.0 EXISTING HEADWORKS BUILDING

The existing coarse screen has reached the end of its service life and is not providing efficient screening prior to the extended aeration system. This failing screen and lack of grit removal allows non-biological solids to enter the aerated lagoon which is exacerbating the lagoon sludge issues. The building and ancillary equipment has also deteriorated significantly and needs replacement. The screen and headworks building will be replaced with a new headworks facility comprising fine screening and grit removal.

2.1 Plant Hydraulics

The proposed changes at the plant will require additional head at the front of the plant.

RVA proposes to elevate the new screen channel and grit removal unit to a level that creates enough positive static head to allow the flow to pass freely to the new aeration tanks and the following downstream processes. The elevation of the new screen channels and grit removal unit will entail the construction of a new upstream influent chamber with a higher outlet level.

Figure 2.1 illustrates conceptual hydraulic layout of the proposed new headworks and aeration tanks.

2.2 Proposed Headworks Building Upgrade

RVA proposes the following actions to upgrade the headworks Building

- Replace the existing influent chamber with a new influent chamber. The new influent chamber will be elevated to provide the required static head to pass the flow to the new elevated screen channels. This scope will entail raising the incoming forcemain to the new level. The existing forcemain and pumps feeding the forcemain will be examined to confirm if they have the require head, and if not, they will be replaced.
- Replace the existing coarse screen with a fine step screen to improve removal of debris. Step screen technology will also remove a portion of the grit and FOG by the “filter mat” that forms on the face of the screen. It is proposed to supply two step screens rated at 200 l/s each, where the capacity of the screens combined will meet the full peak instantaneous flow (PIF) of the plant rated capacity and one screen can handle the ADF.
- Replace the existing screen channel with new channels. The new channels will be higher than the existing channel level to provide the required static head to overcome the downstream head losses. The proposed work will consist of three parallel channels, two channels to hold the step screens and the third channel will be a bypass channel with a manual bar screen.
- Add two Detroiter grit removal units, complete with classifier unit and other required accessories. The grit removal units will assist the fine screen to settle and remove the remaining small size debris that passes through the upstream screen. Combined the grit removal units will be sized to meet the rated capacity. At lower flow periods a single unit will be operated to avoid stagnation and odours.
- Build a new Headworks building on top of the new screen channels to house the screens, grit classifier, and associated electrical and control panels. The new

building and channels will be constructed in a new location to allow the existing facility to operate during the construction of the new facility.

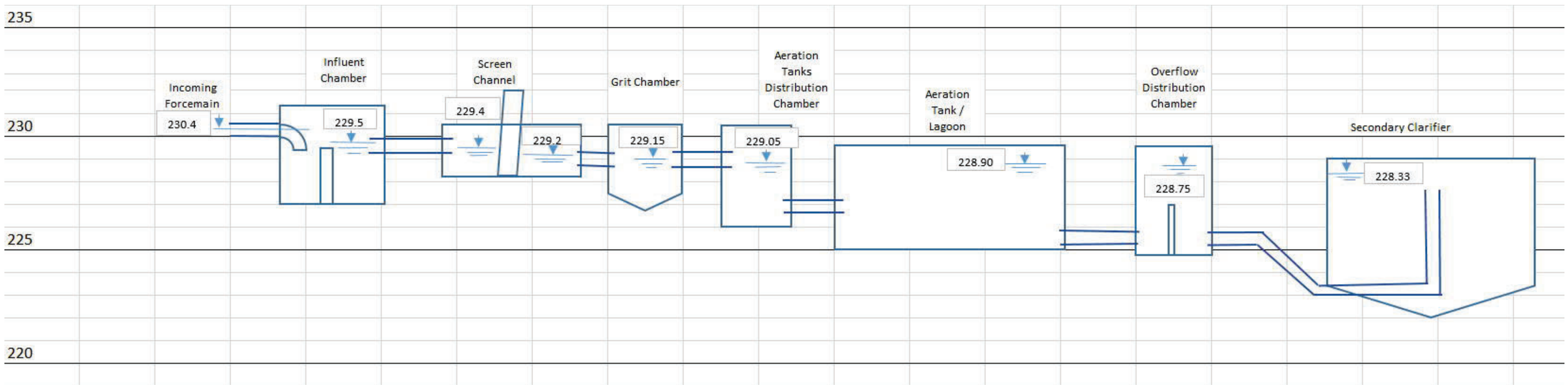

Figure 2.1 – Strathroy WWTP Upgrade – Proposed Hydraulic Profile

3.0 DISCUSSION OF BIOLOGICAL UPGRADE OPTIONS

In line with the Strathroy WWTP requirements, RVA proposes three options to upgrade the biological treatment and provide redundancy to the exiting aerated lagoon.

3.1 Option 1 – Small concrete extended aeration tanks for the current flow, and WWTP conversion to Conventional Activated Sludge system in future.

The concept of this option has two stages. The first stage entails the construction of two extended aeration tanks adequate to handle the current flow rates as indicated in Table 3.1, while the existing aerated lagoon provide operational redundancy. As such, with the full capacity of the existing aerated lagoon still available, the existing rated capacity of 10,000 m^3/d of the WWTP will be retained.

The second stage of this option would entail reconfiguration of the first stage extended aeration system into a CAS system by adding two primary clarifiers and one aerobic digester. This will allow the existing extended aeration tanks from phase 1 to be rated for 10,000 m^3/d. As such, with transference of 100% of the bioreactor capacity to the new tanks. The existing aerated lagoon will be either be decommissioned or reconfigured to a second stage sludge digester, for enhanced digestion and storage.

Table 3.1 – Current Influent Flows and Characteristics

Parameter	Unit	Value
Current Average Daily Flow	m^3/d	5,500
Current Peak Daily Flow	m^3/d	12,804
2nd Stage Plant Rated Capacity	m^3/d	10,000
2nd Stage Plant Rated Peak Capacity	m^3/d	23,280
Influent $cBOD_5$	mg/l	310
Influent TSS	mg/l	399
Influent TKN	mg/l	37
Influent TP	mg/l	4.0

At the current flowrate, the two extended aeration tanks will provide a hydraulic retention time (HRT) of 18 hours and have dimensions of (2 each, 29 m x 14 m x 5 m SWD). Both tanks will receive the screened influent from the upgraded Headworks Unit and will be supplied with sufficient aeration for BOD removal, mixing, and nitrification. The effluent from the extended aeration tanks will flow by gravity to the existing Secondary Clarifier Tanks for solids settlement and RAS/WAS operation. With this mode the new extended aeration tanks will serve the influent flowrate up to an ADF of 6,500 m^3/d. Having two tanks allows one to be taken out of service for maintenance or cleaning. Once the new lagoon is in service the old lagoon will be taken offline to be cleaned and upgraded with a new aeration system. The existing aeration lagoon will be retained for operational redundancy and to avoid de-rating of the plant but will be kept off-line except in an emergency.

When the plant ADF approaches 6,500 m^3/d, the extended aeration system will be converted into a CAS system by constructing two primary clarifier tanks and one aerobic digestion tank. The first stage extended aeration tanks will provide 9.9 hours HRT for the rated capacity of 10,000 m^3/d under the CAS mode, which is higher than MECP guideline of minimum HRT of 6.0 hours for CAS aeration tank.

The proposed second stage (CAS System) aerobic digester will provide a storage capacity of 10 days sludge production and the sludge will continue to be stabilized in the sludge storage lagoon. Once the second stage is complete the existing aeration lagoon will become redundant and could either be decommissioned or reconfigured for waste sludge stabilization/storage in future.

Future expansion beyond 10,000 m3/d would require additional tankage and secondary clarifiers. It would be possible to put the old lagoon back into service to gain additional capacity as an alternate to new concrete tanks. Additionally, the final filters would require an upgrade.

3.2 Option 2 – Large Concrete Extended Aeration Tanks for the plant rated capacity of 10,000 m^3/d

This option includes provision of two concrete extended aeration tanks sized for the WWTP rated capacity of 10,000 m^3/d. The tanks will provide 18 hours HRT at 10,000 m^3/d and have dimensions of 42 m x 18 m x 5 m (L x W x SWD) each. Having two tanks allows one to be taken out of service for maintenance or cleaning. With this larger extended aeration tanks option, the existing aeration lagoon will become redundant and could either be decommissioned or reconfigured for waste sludge stabilization/storage in future.

Future expansion beyond 10,000 m3/d would require additional tankage and secondary clarifiers. It would be possible to put the old lagoon back into service to gain additional capacity as an alternate to new concrete tanks. Additionally, the final filters would require an upgrade.

3.3 Option 3 – Utilization of the existing south lagoon to build one new lagoon for the plant rated capacity of 10,000 m^3/day.

In option three, a part of the former decommissioned lagoon cell, located south of existing aerated lagoon, will be utilized to build one new lagoon cell able to treat the plant rated capacity of 10,000 m^3/day. The decommissioned cell will be refurbished and an aerated cell equal in size to the existing aerated lagoon will be constructed by addition of a new south berm. A lining and floating aeration system will be installed and connected to the exiting air blowers to supply the required aeration to the lagoon. Once the new lagoon is in service the old lagoon will be taken offline to be cleaned and upgraded with a new aeration system.

With this option, the Strathroy WWTP will have one new lagoon with total rated capacity of 10,000 m^3/day and after refurbishment of the existing lagoon, another 10,000 m3/day lagoon which will be available as a 100% redundancy to allow for maintenance and cleaning.

The next stage of expansion beyond 10,000 m3/d would be the addition of additional secondary clarifiers. This would allow both of the extended aeration lagoons to be used simultaneously to increase the plant capacity. Additionally, the final filters would require an upgrade.

4.0 ANALYSIS OF BIOLOGICAL UPGRADE OPTIONS

To evaluate the proposed options, RVA conducted desktop design calculations and BioWin modeling to assess the plant operation and determine sludge production rates.

4.1 Option 1 Analysis

Desktop calculation and BioWin modeling were conducted to calculate the plant dimensions and operational data for option one. The Extended Aeration Tanks dimensions for the influent current average flows are shown in the following Table 4.1

Table 4.1 – Option 1 - Operation Summary – Extended Aeration Mode

Parameter	Unit	Current ADF
Average Daily Flow	m^3/d	5,500
Peak Daily Flow	m^3/d	12,804
Aeration tank HRT	h	18
SRT	d	15
Aeration tank volume- total	m^3	4125
Number of aeration tanks	-	2
Aeration tank volume- each	m^3	2063
Aeration tank MLSS	mg/l	5145
Secondary clarifier surface area	m^2	795
Solids loading on secondary clarifier at PDF	$kg/(m^2.d)$	70

The proposed Extended Aeration Tanks will treat the current flowrates. However, the same Extended Aeration Tanks will be upgraded to CAS system to treat the rated capacity. Table 4.2 shows the CAS system tanks dimensions.

Table 4.2 – Option 1 - Operation Summary – CAS Mode

Parameter	Unit	Rated Capacity
Rated Average Daily Flow	m^3/d	10,000
Rated Peak Daily Flow	m^3/d	23,280
CAS Aeration Tank HRT	h	9.9
SRT	d	8
CAS Aeration Tanks Volume	m^3	4125
Assumed CAS Aeration Tank SWD	m	5
Extended Aeration Number of Tanks	-	2
Extended Aeration Tank volume- each	m^3	2063
Aeration tank MLSS	mg/l	3348
Primary Clarifier SOR PDF	$m^3/(m^2.d)$	60
Primary Clarifier Assumed SWD	m	4
Primary Clarifier Number of Tanks	-	2

Primary Clarifier One Tank Surface Area (ADF)	m^2	167
Primary Clarifier One Tank Surface Area (PDF)	m^2	194
Secondary clarifier surface area	m^2	795
Solids loading on secondary clarifier at PDF	kg/ (m^2.d)	120
Aerobic Digester		
Sludge Production	m^3 /d	124
Sludge solids concentration	%	3
Solids retention Time in CAS, SRT	d	8
Recommended SRT for aerobic sludge stabilization	d	45
Design SRT of new digester tank	d	10
Solids destruction in for 10-day SRT	d	10%
Partially digested sludge volume from new digester	m3	112
Aerobic Digester Volume	m3	1116
Aerobic Digester SWD	m	4.5
Aerobic Digester total Surface Aera	m2	248
Aerobic Digester Length	m	20
Aerobic Digester Width	m	12
Digester SRT in Aerated lagoon cell	d	27
Volume of lagoon digester cell	m3	3013

Figure 4.1 illustrates the conceptual site layout of option one after full upgrade to CAS system.

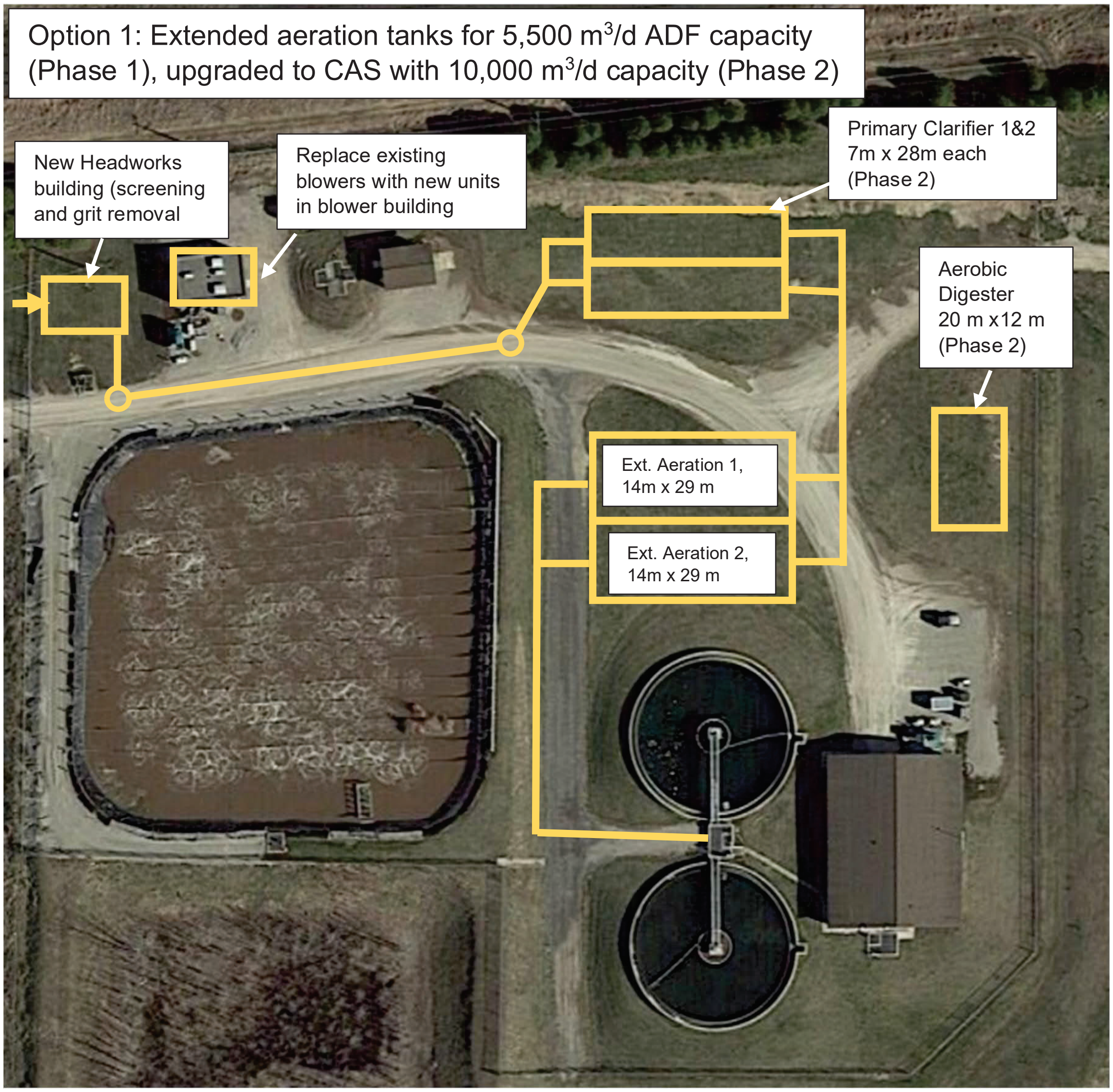

Figure 4.1 – Conceptual Site Layout – Option 1

4.2 Option 2 Analysis

The Extended Aeration Tanks dimensions of option two were calculated as shown in the following Table 4.3.

Table 4.3 – Option 2 - Operation Summary

Parameter	Unit	Rated Capacity
Average Daily Flow	m^3/d	10,000
Peak Daily Flow	m^3/d	23,280
Minimum Extended Aeration HRT	h	18
SRT	d	15
Aeration Tanks Volume	m^3	7500
Aeration Tank SWD	m	5

Parameter	Unit	Rated Capacity
Aeration Surface Area	m^2	1500
Number of Tanks	-	2
Aeration tank MLSS	mg/l	5102
Secondary clarifier surface area	m^2	795
Solids loading on secondary clarifier at PDF	kg/ (m^2.d)	196

Figure 4.2 illustrates the conceptual site layout of option two Extended Aeration System.

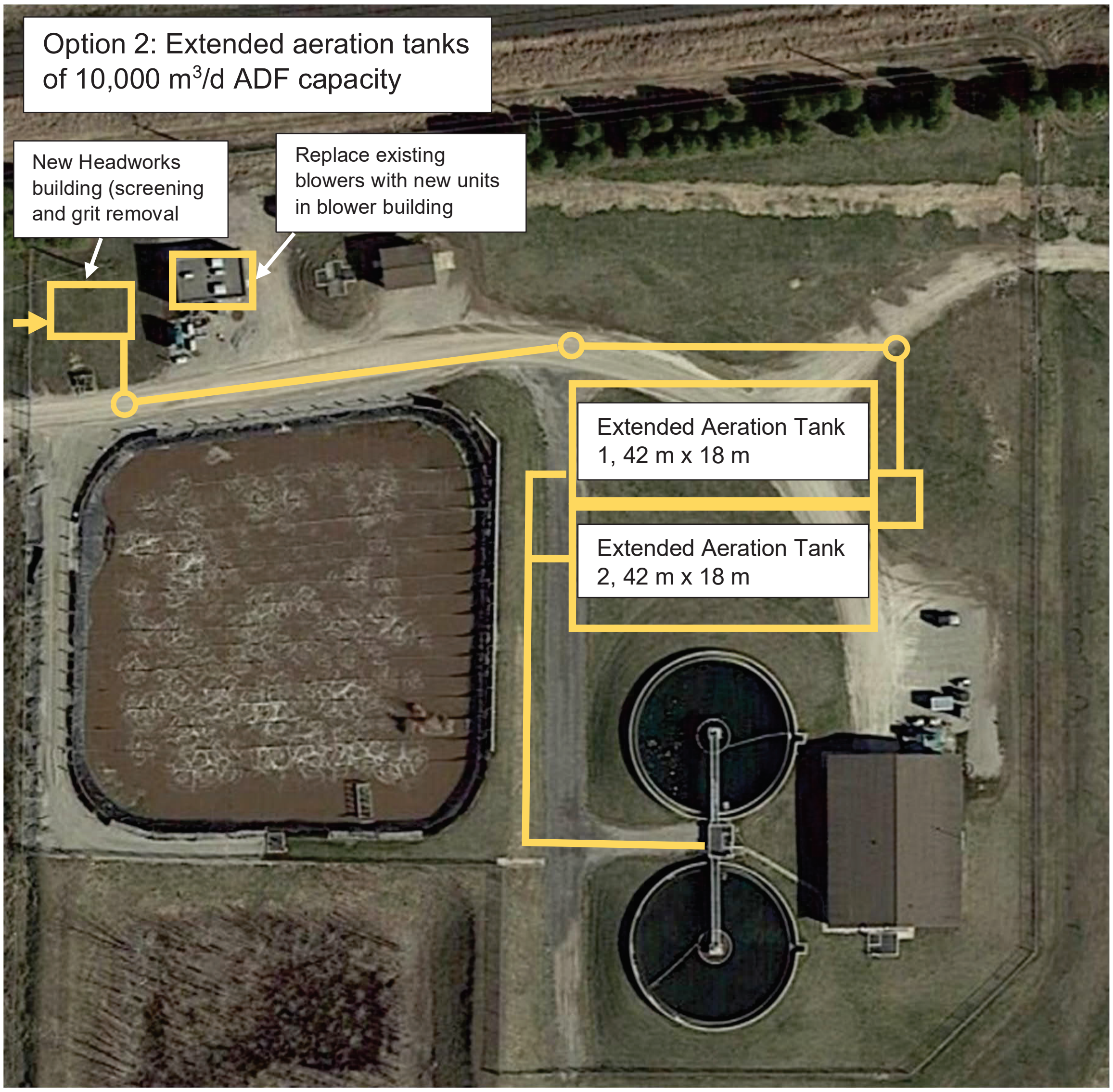

Figure 4.2 – Conceptual Site Layout – Option 2

4.3 Option 3 Analysis

The Aerated Lagoon dimensions of option three were calculated as shown in the following Table 4.4

Table 4.4 – Option 3 - Operation Summary

Parameter	Unit	Rated Capacity
Average Daily Flow	m^3 /d	10,000
Peak Daily Flow	m^3 /d	23,280
Aerated Lagoon Volume	m^3	8,780
Aerated Lagoon SWD	m	3.45
Aerated Lagoon Top Surface Area (61mx61m)	m^2	3,721
Aerated Lagoon Bottom Surface Area (37mx37m)	m^2	1,369
Extended Aeration One Tank Surface Area	m^2	750
Aerated Lagoon Length	m	61
Aerated Lagoon Width	m	61
Aerated Lagoon HRT	h	21

Figure 4.4 illustrates the conceptual site layout of option three Aerated Lagoon System.

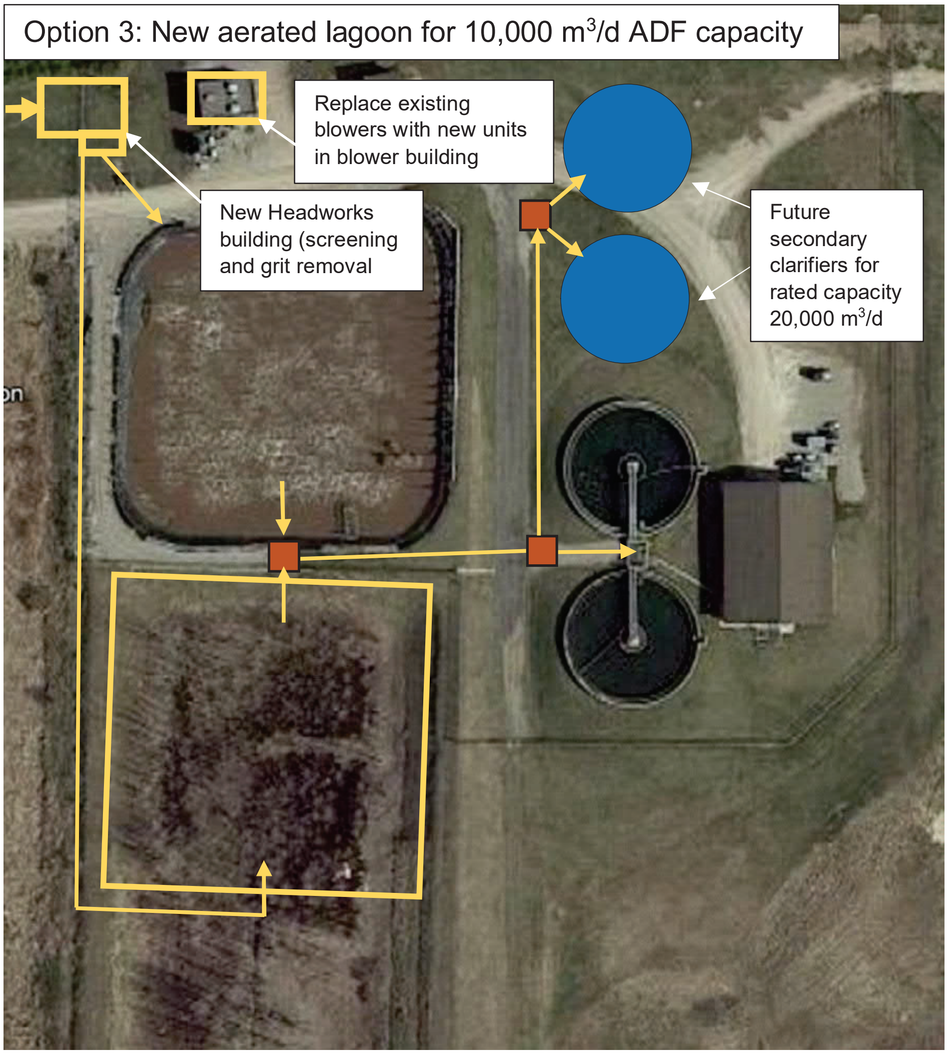

Figure 4.3 – Conceptual Site Layout – Option 3

5.0 EVALUATION OF BIOLOGICAL UPGRADE OPTIONS

5.1 Option 1 Evaluation

Option one provides a solution for the lagoon issue by providing two smaller extended aeration tanks (1st stage) suitable to handle the current flowrates. However, when the influent flowrate starts to increase to higher levels, the plant will be upgraded to a CAS treatment process for the plant rated capacity. The first stage extended aeration tanks will be utilized as CAS bioreactors to handle the plant rated capacity by adding two primary clarifier tanks and one aerobic digester with the use of the existing secondary clarifier tanks.

The CAS system in option one gives redundancy to the operation by having two tanks for each of the plant processes. This feature would also give the flexibility to operate the plant at lower flowrates with less energy consumption by running a single tank only.

Table 5.1 shows option one footprint will be approximately 1,444 m^2.

Table 5.1. – Option 1 Footprint

Option one Tanks	Number	Total Surface Area, m^2	Tank SWD, m	Status
Extended Aeration / CAS Aeration Tank	2	812	5	New
Primary Clarifier	2	392	4	New
Aerobic Digester	1	240	4.5	New
Secondary Clarifier	2	795	4	Exist
Total New Footprint		1,444		

A Level D cost estimate of option one is $18,900,000 as summarized in Table 6.1.

5.2 Option 2 Evaluation

Option two provides a single stage solution for the lagoon issue by providing two larger extended aeration tanks capable of handling the plant rated capacity with the use of the existing secondary clarifier tanks. Having two extended aeration tanks in option two, gives the redundancy and flexibility to operate one tank only with the current lower flows and save on aeration energy. Table 5.2 indicates option two footprint will be approximately 1,500 m^2.

Table 5.2 – Option 2 Footprint

Option Two Tanks	Number	Total Surface Area, m^2	Tank SWD, m	Status
Extended Aeration	2	1500	5	New
Secondary Clarifier	2	795	4	Exist
Total New Footprint		1500		

A Level D cost estimate for option two is $15,100,000 as summarized in Table 6.1.

With option two, the existing lagoon provides sufficient capacity for waste sludge storage and further stabilization, and this would limit the need for an aerobic digester.

5.3 Option 3 Evaluation

Option three provides a single stage solution for the existing lagoon issue by utilizing part of the existing south lagoon by building a berm on one side of the lagoon to provide a rectangular lagoon with volume of approximately 8,780 m^3. This new lagoon will be covered by a polymer lining and provided with floating aeration system. The new aerated lagoon will be sized to meet the plant rated capacity of 10,000 m^3/day and it will provide 100% redundancy to the existing north lagoon.

Upon completion of all maintenance works in the existing lagoon, the north lagoon will be ready for operation / standby with the new south lagoon.

Table 5.3 indicates option three footprint will be approximately 3,721 m^2 but on the existing south lagoon.

Table 5.3 – Option 3 Footprint

Option Three Lagoon	Number	Total Surface Area, m^2	Tank SWD, m	Status
South Lagoon	1	3,721	3.45	New
North Lagoon	1	3,000	3.45	Exist
Total New Footprint		3,721		

A Level D cost estimate of option three is $10,400,000 as summarized in Table 6.1.

With option three, the existing lagoon provides sufficient capacity for waste sludge storage and further stabilization, and this would limit the need for an aerobic digester.

5.4 Sludge Storage Lagoon

A desktop analysis was conducted to calculate the sludge that has been produced by the Strathroy WWTP and stored in the sludge storage lagoon. The estimated average depth of the settled sludge layer at the lagoon bottom is less than 20cm after 40 years of operation, indicating significant residual capacity for further sludge storage in future.

However, the Municipality should perform a regular check on the sludge storage lagoon operation and the sludge deposit development in the lagoon

6.0 COST ESTIMATES

Level D cost estimates were completed to compare each option. Table 6.1 gives a summary of capital cost breakdowns. These estimates only include costs to meet the existing 10,000 m^3/d rated capacity. Expansion beyond that capacity will be additional cost.

Table 6.1 – Cost Estimates

Item	Option One	Option Two	Option Three
Demolition and removals	100,000	100,000	100,000
New Headworks Building	1,600,000	1,600,000	1,600,000
Existing Blowers Building Upgrade	100,000	100,000	100,000
Existing Filtration Building Upgrade	100,000	100,000	100,000
Primary Clarifier	1,554,000	-	-
Aeration Tanks / Lagoon	2,894,500	4,289,500	1,970,000
Aerobic Digester	1,769,000	-	-
Electrical and Controls	450,000	450,000	450,000
Genset (back-up power)	320,000	320,000	320,000
Lagoon Sludge Management[1]	500,000	500,000	500,000
Site grading and landscaping	50,000	50,000	50,000
SUB-TOTAL - 1	**9,437,500**	**7,509,500**	**5,190,000**
Bonds and Insurance[2]	377,500	300,380	207,600
Mobilization & Demobilization[3]	471,875	375,475	259,500
Contractor Mark-Up[4]	1,415,625	1,126,425	778,500
Construction Contingency[5]	943,750	750,950	519,000
SUB-TOTAL - 2[6]	**12,646,250**	**10,062,730**	**6,954,600**
Estimating contingency[7]	3,793,875	3,018,819	2,086,380
Capital Cost[8]	**16,400,000**	**13,100,000**	**9,000,000**
Engineering cost[9]	2,460,000	1,965,000	1,350,000
TOTAL PROJECT COST[10]	**18,900,000**	**15,100,000**	**10,400,000**

1. Removal of sludge from the existing aeration lagoon and haul if for land application or landfill.
2. 4% of sub-total 1
3. 5% of sub-total 1
4. 15% of sub-total 1
5. 10% of sub-total 1
6. Sub-total 1 plus overheads
7. 30% of sub-total 2
8. Sub-total 2 plus estimating contingency
9. 15% of Capital cost
10. Capital plus engineering cost

7.0 CONCLUSION

All proposed options are designed to handle up to the plant rated capacity and give redundancy and flexibility to handle different flow patterns.

Option one with an estimated capital cost $18,900,000, entails more complex operational requirements with the addition of primary clarifiers and an aerobic digester system. Furthermore, aerobic digestion of primary sludge can lead to odour issues which is an additional operational challenge.

Option two provides two extended aeration tanks that can handle the plant rated capacity with an estimated capital cost of $15,100,000 which is approximately 80% of the estimated capital cost of option one. Option two is reliable and a good solution for the existing lagoon issue. Option two provides full redundancy to the existing lagoon and with the option of two tanks, it can provide savings on the power consumption by operating one tank only with the current flowrate.

Option three with the additional lagoon option is a more economical option compared to the concrete tanks' options. The decommissioned lagoon cell south of the existing aerated lagoon is available for upgrading and only needs to be divided to the required volume by building a berm at one side of the lagoon to form a rectangular shape with the required lagoon volume. With an estimated cost of $10,400,000, option three is approximately 55% of the estimated cost of option one and 69% of the estimated cost of option two.

Unlike options one and two, option three will use part of the land of the already existing unused lagoon and will not use any other land within Strathroy WWTP facility.

Therefore, Option 3, being the most cost-effective and optimal of the three options, is recommended as the preferred option for the existing WWTP upgrade.