# LEONI TOWNSHIP

## JACKSON COUNTY, MI

# WASTEWATER TREATMENT PLANT MEMBRANE REPLACEMENT EVALUATION


FLEIS&VANDENBRINK
DESIGN. BUILD. OPERATE.

November 2019

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# EXECUTIVE SUMMARY

This report presents alternatives for replacement of the existing membrane bioreactors at the Leoni Township Wastewater Treatment Plant. The existing membrane treatment technology provides secondary treatment utilizing Kubota flat plate membranes organized into five treatment trains. The membranes are approaching their 10-year useful life and are exhibiting increased fouling and failure rates. The system is designed so that only four of the treatment trains are needed to handle average daily flows and all five trains are required for when the plant experiences peak flows. Each train has a dedicated permeate pump and three blowers are used to provide the air required.

Since the original membranes were installed, technology has evolved, and more efficient systems are available. For this evaluation, proposals for new membrane systems were received from three prominent manufacturers: SUEZ (formerly General Electric (GE)), Koch, and FibraCast. The SUEZ and Koch membrane systems utilize hollow-fiber ultrafiltration, while the FibraCast system is a hollow-fiber/flat sheet hybrid system. Each option evaluated requires fewer tanks than currently utilized to handle the same flows. Additionally, because each equipment option requires less depth within the tank, the tank floor can be sloped to help collect fine grit and provide a means to help alleviate the buildup that currently occurs within these basins. Each option includes replacement of the existing permeate pumps, membrane blowers, and aeration blowers.

A net present worth analysis was completed that included an Engineer's Opinion of Probable Project Cost for each of the three manufacturers and estimated annual operation and maintenance costs. The economic analysis performed indicates that Koch has the lowest capital cost but the greatest annual operation and maintenance costs. While FibraCast requires the largest capital expenditure, its annual costs are relatively low. SUEZ falls in the middle of Koch and FibraCast for both capital and annual costs. Overall, Koch has the lowest net present worth.

A number of factors in addition to cost were also considered such as customer service, replacement part availability, and manufacturer's reliability. Site visits with Township officials were completed to three wastewater treatment plants operating with SUEZ's membrane system and FibraCast's membrane system to review the installations and learn about the equipment from the operators' perspectives. Operators at plants with SUEZ equipment installed reported that they were extremely pleased with the performance of the membranes as well as the support received from SUEZ. In addition to those plants visited, there are over 70 plants across North America in the municipal sector with a capacity greater than 1.0 MGD operating SUEZ membrane equipment systems. A number of systems have extensive history working with SUEZ/GE dating back decades and many have demonstrated a membrane life greater than 10 years. This has significantly increased confidence in the performance of the equipment.

In October 2019 a meeting was held with Township officials to review the different technologies and discuss the anticipated capital and operation and maintenance costs associated with each. To best meet the Township's needs, it is recommended that the existing membrane technology be replaced to avoid failure of the secondary treatment system at the WWTP. The preferred manufacturer is SUEZ due to the long-term success of its membranes in similar plants, the operational and maintenance requirements, and the customer support available from SUEZ as well as support available from operators of SUEZ equipment at other plants throughout Michigan.

Along with replacing the membrane equipment system, SUEZ proposed an option to modify the biological processes. The proposed changes include adding aeration to the existing anoxic zone. This would provide the benefit of increasing reliability of the membranes by separating the biological treatment from the ultrafiltration. Because these proposed changes do not directly impact the design or implementation of the membrane equipment itself, these improvements may be implemented in the future as flows and loadings change.

It is recommended that the Township budget to replace the membrane equipment system and to make improvements to the biological treatment processes. The total recommended project budget is $9,700,000. This includes demolition, tank modifications, installation of new membranes, replacement of the membrane and the pre-aeration blowers, a new membrane cleaning system, installation of new permeate pumps, piping and valves, installation of new diffusers in the existing Anoxic Basin, and electrical and controls. Construction contingency, engineering, and administration costs are also included in the recommended project budget.

Available options for funding this project include municipal bonds and the Clean Water State Revolving Fund (SRF). A municipal financial advisor should be consulted to determine the best source of funding for the project. A Part 41 Construction Permit will be required from EGLE prior to beginning construction. It is estimated that the membrane replacement project could be designed, bid, constructed, and operational in 24 to 30 months following authorization to proceed by the Township.

# 1.0 BACKGROUND AND PURPOSE OF REPORT

Leoni Township retained Fleis & VandenBrink to evaluate membrane replacement alternatives at the Leoni Township Wastewater Treatment Plant (WWTP). The facility was originally constructed in 2010 and utilizes membrane bioreactors (MBRs) for secondary treatment. The membranes and associated control systems are approaching the end of their 10-year expected useful life.

In recent years, the membranes have experienced increased fouling, requiring additional maintenance for periodic cleaning to restore treatment capacity. Additionally, the membranes are exhibiting signs of wear and increasing failure rates of individual membrane filter plates. Replacement filter plates have become difficult to obtain and the costs associated with membrane filter plate replacement are significant. Therefore, replacement of individual membrane filter plates on an as needed basis is not sustainable as a long-term solution.

Since the original membranes were installed, treatment technology has evolved, and the Township would like to consider other membrane technologies other than flat plate style units and their impacts on plant operations. Improved technologies have the potential to reduce the required footprint allowing for future expansion, reduce operation and maintenance requirements, and increase membrane performance and reliability.

The purpose of this report is to provide a preliminary engineering evaluation and recommendation for replacing the MBR equipment at the WWTP. Detailed design will be required following this report for the recommended alternative.

# 2.0 Existing Facilities and Future Flows and Loads

## 2.1 Existing Flows and Loads

Daily monitoring reports from January of 2017 through June of 2019 were obtained and summarized to determine the current plant capacity being utilized. Table 1 provides a summary of the recent plant influent flows, pollutant concentrations and loads. These values are compared to the facility's design mass loadings. The data reviewed indicates that the plant has sufficient capacity for its current operations.

**Table 1. Influent Flow, Concentration, and Loading[1]**

| | Flow | | $CBOD_5$ | | Total Suspended Solids | | Ammonia ($NH_3$-N) | | Total Phosphorus | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Annual Avg. | Max Day | | | | | | | | |
| | mgd | mgd | mg/L | lbs/d | mg/L | lbs/d | mg/L | lbs/d | mg/L | lbs/d |
| 2017-2019 | 1.73 | 3.560 | 263 | 3,697 | 430 | 6,037 | 36.4 | 519 | 8.2 | 116 |
| Basis of Design | 3.00 | 4.80 | 323 | 8,082 | 368 | 9,207 | 42.0 | 1,051 | 11.0 | 275 |
| Capacity Used | 58% | | | 46% | | 66% | | 49% | | 42% |

[1] *Loading based on average daily flow.*

## 2.2 Existing Facilities

The existing WWTP is an activated sludge plant designed to treat an average of 3.0 million gallons per day (MGD) of raw sewage. The original WWTP was a facultative lagoon facility that was constructed in 1971. In 2010 major upgrades occurred to modernize the facility. Improvements included abandonment of the lagoon treatment system and the construction of a Headworks Building featuring grit removal and fine screening, three pre-anoxic tanks, three pre-aeration tanks, five MBR basins, two ultraviolet disinfection banks, cascade aeration steps, and an effluent pump station. One lagoon still serves as equalization during high flow events. Influent wastewater is received by the plant from 13 communities. Appendix A provides the basis of design for the WWTP.

The existing MBR system provides secondary treatment and is comprised of five treatment trains. Average daily flows can be treated with one train out of service while all five are needed for peak flows. Flow to the MBR basins is received from the Post-Anoxic Channel and distribution is controlled by manually operated weir gates.

The purpose of the membrane is to separate biological solids from the mixed liquor, producing a high-quality effluent. In the existing membrane system, permeate from the membranes is collected in individual headers for each basin and is discharged to a common permeate header. Permeate flows through this header to the final effluent pumping station via gravity. Permeate pumps provide the ability to re-prime the gravity discharge or to supplement flows from the MBR basins in the case of insufficient head pressure. The solids that are retained within the MBR basin flow from the bottom of the MBR basins into the return activated sludge (RAS) weir box. The sludge flows by gravity back to the recycle channel located upstream of the pre-aeration basin. Waste Activated Sludge (WAS) Pumps allow for the wasting of sludge from the RAS system once sludge levels increase in the treatment process.

The existing membrane Clean in Place (CIP) system is a manual operation that is initiated when the Trans Membrane Pressure (TMP) increases to certain pressure. Sodium hypochlorite and oxalic acid are currently used for membrane cleaning.

## 2.3 Existing Discharge Permit

The current National Pollutant Discharge Elimination System (NPDES) permit for the WWTP sets effluent concentration and load limits for discharge to an unnamed tributary of the Grand River. The permit expires

October 1, 2022 and is typically renewed for another five-year period. A summary of the discharge limitations is presented in Table 2. For the purposes of this evaluation, NPDES permit limits are anticipated to remain the same.

**Table 2. NPDES Permit No. MI0045942 Summary**

| | Max. Limits for Quantity or Loading | | | | Max. Limits for Quality or Concentration | | | |
|---|---|---|---|---|---|---|---|---|
| **Parameter** | **Monthly** | **7-Day** | **Daily** | **Units** | **Monthly** | **7-Day** | **Daily** | **Units** |
| Flow | Report | --- | Report | MGD | --- | --- | --- | --- |
| $CBOD_5$ | | | | | | | | |
| May 1 - Nov 30 | 100 | 250 | Report | lbs/day | 4 | --- | 10 | mg/L |
| Dec 1 – March 31 | 580 | 850 | Report | lbs/day | 23 | --- | 34 | mg/L |
| April 1 - 30 | 600 | 900 | Report | lbs/day | 24 | --- | 36 | mg/L |
| Total Suspended Solids | | | | | | | | |
| May 1 - Nov 30 | 500 | 750 | Report | lbs/day | 20 | 30 | Report | mg/L |
| Dec 1 – April 30 | 750 | 1100 | Report | lbs/day | 30 | 45 | Report | mg/L |
| Ammonia Nitrogen | | | | | | | | |
| May 1 - Nov 30 | 13 | 50 | Report | lbs/day | 0.5 | --- | 2 | mg/L |
| Dec 1 – March 31 | 290 | 430 | Report | lbs/day | 11.4 | --- | 17 | mg/L |
| April 1 - 30 | 330 | 380 | Report | lbs/day | 13.3 | --- | 15 | mg/L |
| Total Phosphorus | 8.3 | --- | Report | lbs/day | 0.33 | --- | Report | mg/L |
| E. coli | --- | --- | --- | --- | 200 | 400 | Report | cts/100mL |
| Available Cyanide | 0.17 | --- | Report | lbs/day | 7 | --- | Report | ug/L |
| Total Selenium | 0.16 | --- | Report | lbs/day | 6.0 | --- | Report | ug/L |
| Total Mercury | | | | | | | | |
| | **Min. Limits for Quality or Concentration** | | | | **Limits for Quality or Concentration** | | | |
| **Parameter** | **Monthly** | **7-Day** | **Daily** | **Units** | **Parameter** | **Min. Daily** | **Max. Daily** | **Units** |
| TSS Min. % Removal | | | | | pH | 6.5 | 9.0 | S.U |
| Dec - April | 85 | --- | --- | % | Dissolved Oxygen | | | |
| | | | | | May 1-Sep 30 | 7.0 | --- | mg/l |
| | | | | | Oct 1-Nov 30 | 6.0 | --- | mg/l |

## 2.4 Future Flows and WWTP Capacity

The design flows for the existing facility are shown in Table 3. Population growth projections were gathered from the United States Census Bureau and the Region 2 Planning Commission for each of the member-communities that provide flow to the WWTP and were used in determining 20-year projected flows. The 2018 population served by the WWTP totals 27,272. The projected 2039 design population is estimated at 28,749. Projected flows associated with this design population are show in the following table.

**Table 3. Existing WWTP Hydraulic Capacity and Projected Flows**

| Parameter | Design Plant Capacity (gpd) | 2017-2019 (gpd) | Projected 2039 (gpd) |
|---|---|---|---|
| Average Daily Flow | 3,000,000 | 1,700,000 | 1,830,000 |
| Maximum Daily Flow | 4,800,000 | 3,000,000 | 3,760,000 |
| Maximum Month Average Daily Flow | 3,000,000 | 2,400,000 | 2,510,000 |

# 3. 0 Improvement Alternatives

## 3.1 Summary of Required Improvements

Replacement of the existing Kubota flat-plate style membranes with a more efficient technology is recommended to meet the Township's future needs. Improved technology has been developed since the time of original installation, making equipment more reliable and less maintenance intensive. The existing Kubota membranes were represented by Ovivo until recently. Ovivo no longer supplies flat-plate membrane systems and was not able to supply a proposal for a replacement-in-kind system.

Proposals for new membrane systems were received from three prominent manufacturers, SUEZ (formerly General Electric (GE)), Koch and FibraCast. There are various similarities between the membrane treatment systems and some important differences. Process site layout schematics for each manufacturer are presented in Figures 1a and 1b for SUEZ, Figure 2 for Koch, and Figure 3 for FibraCast, and are found in Appendix B.

Table 4 provides a summary of the identified the proposed improvements by manufacturer. The rest of this section evaluates each unit process for capacity and condition related issues that should be addressed in the membrane replacement project.

| Table 4. Summary of Proposed Improvements | | | |
|---|---|---|---|
| **Parameter / Characteristic** | **SUEZ** | **Koch** | **FibraCast** |
| Influent force main | No modifications required at this time | | |
| Grit removal | No modifications required at this time | Improvements to the grit removal system are not required. However, MBR manufacturers acknowledge that existing grit loads may reduce the expected useful life of MBR equipment. | |
| Fine screens | No modifications required at this time | | |
| Anaerobic basin | Proposed option to convert to anoxic zone | No modifications required at this time | |
| Anoxic basin | Proposed option to convert to aerobic zone with fine bubble diffusers | No modifications required at this time | |
| Feed forward pumps | No modifications required at this time | | |
| Pre-aeration basin | No modifications required at this time | | |
| Fine bubble aeration diffusers | Proposed installing additional fine bubble diffusers in existing Anoxic basin | No modifications required at this time | |
| MBR basin | Take two existing tanks out of service. Slope existing tank floor for solids removal. | Take one existing tank out of service. Raise tank floor and slope for solids removal. | Take three existing tanks out of service. Demo wall between two remaining tanks and construct new walls to create three smaller tanks. Raise tank floor and slope for solids removal. |
| MBR membranes | Replace existing with 18 cassettes | Replace existing with nine cassettes | Replace existing with 20 cassettes |
| Pre-aeration blowers | Replace existing with new blowers sized for process | | |
| MBR blowers | | | |
| Controls | New control panel and new programming for SCADA | | |
| Permeate pumps | Replace existing with rotary-lobe style pumps | | |
| UV Disinfection | No modifications required at this time | | |
| Outfall | No modifications required at this time | | |
| Solids handling facilities | No modifications required at this time | | |
| Ferric chloride feed | No modifications required at this time | | |
| Membrane CIP system | Continue use of sodium hypochlorite; Discontinue use of oxalic acid and instead use citric acid; Automate cleaning schedules | | |
| Emergency power system | No modifications required at this time | | |

## 3.2 Headworks Facilities

The Headworks Building receives sewage from the collection system through a 24-inch forcemain. A vortex grit system including grit washer and classifier is used for grit removal. This is followed by two rotary fine screens.

Two of the equipment manufacturers considered for this evaluation, Koch and Fibracast, indicated that the expected useful life of their membranes may be reduced by the existing grit load that accumulates in the MBR tanks. If these technologies are chosen, a new grit removal system should be given consideration to maximize the life of the membranes. A new stacked tray grit system may provide increased protection for the membranes compared to the existing grit removal system due to its higher capture rate for finer materials. SUEZ does not anticipate the existing grit load to impact membrane performance or reliability.

The existing 2 mm Huber fine screens are sufficient to meet each manufacturer's influent screening requirements and would not require replacement with this project.

## 3.3 Anaerobic Basins

The three Anaerobic Basins receive flow from the splitter box (following the fine screens) and internal recycle flow from the Pre-Aeration Basins. The Anaerobic Basins are followed by a Recycle Channel that allows mixing with return activated sludge (RAS) from a 24-inch gravity line from the MBR Basins.

In addition to their baseline proposal, SUEZ also discusses the option of repurposing the existing Anaerobic Basins as Anoxic Basins and the existing Anoxic Basins as additional Aeration Basins to create a more robust treatment system plantwide. Although these modifications are not a requirement, they offer the benefit of separating the biological treatment processes from the ultrafiltration performed by the MBR, resulting in increased reliability of the membranes in addition to simplifying operations. In this option, the RAS would be returned into the new Anoxic Basin (the existing Anaerobic Basin) requiring modifications to the RAS piping and the Recycle Channel. Figure 1b outlines these suggested modifications to the biological treatment process.

## 3.4 Anoxic and Pre-Aeration Basins

The three Anoxic Basins receive flow from the Recycle Channel. There are two submersible pumps (referred to as feed forward pumps) in each tank that feed influent wastewater and RAS into the Pre-Aeration Tanks. Each of the existing feed forward pumps is designed to pump 1,600 gallons per minute (gpm). The existing feed forward pumps will meet each manufacturer's total feed forward flow based on firm capacity (one pump out of service).

The volume of each Anoxic Basin is 104,800 gallons. The purpose of these tanks is to recover some of the alkalinity consumed by nitrification in the Pre-Aeration Basin.

The Pre-Aeration Basins are designed to add air to the wastewater to facilitate aerobic biological growth. Fine bubble diffusers are used to infuse air into the wastewater and mixers are used to homogenize the aerated wastewater. Wastewater flows from the Pre-Aeration Basins into the Post-Anoxic channel which distributes wastewater to the membrane basins.

As discussed in Section 3.3, SUEZ proposes an option for repurposing the existing Anoxic Basin as additional Aerobic Basins where BOD would be oxidized and most of the ammonia would be converted to nitrate. If selected, this option would require the installation of fine bubble diffusers in these basins. The process air supply required for both the proposed Aeration Basin (existing Anoxic Basin) and the existing Pre-Aeration Basin would be achieved with two 2,500 scfm blowers plus one standby blower. These would replace the existing blowers that supply air to the existing Aeration Basins. No modifications are proposed to the aeration equipment located within the existing Pre-Aeration Basins.

## 3.5 Membrane System

The purpose of this study is to evaluate the replacement of the existing membrane system. Advances have occurred in membrane technology since installation of the original MBR units in 2010 which allow for higher capacity membrane systems to be installed within the existing footprint.

Three leading manufacturers, SUEZ, Koch and FibraCast, provided technical and budgetary proposals for their membrane systems and associated biological system design. The design conditions provided to each manufacturer were identical. The SUEZ and Koch membrane systems utilize hollow-fiber ultrafiltration, while the FibraCast system is a hybrid hollow-fiber/flat sheet system.

The SUEZ ultrafiltration hollow fiber PVDF reinforced membrane utilizes a 0.04 micron pore size. Ultrafiltration occurs as the water permeates through the fibers and into the hollow interior while solids and bacteria are unable to pass through. The fibers are arranged in vertical modules secured in cassettes only at the top and bottom. The middle of each fiber is allowed to move freely to reduce the potential for sludge buildup. Continuous aeration using large bubbles assists in scouring the fibers and occurs regardless of whether permeate is being drawn through. Each MBR train utilizes a single air header and a single permeate header. Although robust, there exists the possibility that a fiber could break. In this event, the membrane maintains operation due to the fact that the narrow opening of the fiber that is exposed as a result of the break is quickly plugged by the solids in the water. A broken fiber would not require a cassette to be removed for repair, nor would it reduce the treatment capacity of the membrane.

The Koch single-header ultrafiltration membrane module features reinforced, braided 0.03 micron PVDF hollow fibers that are fixed at the bottom in bundles. The sealed upper ends of the fibers are allowed to float freely to assist in eliminating the accumulation of fibrous materials and sludge solids near the top of the fibers that may reduce available filtration area. Permeate is drawn through the membrane to the interior of the fibers and is collected through a permeate header at the bottom of the bundle. An aeration nozzle is centered at the bottom of each fiber bundle to scour the entire length of the fibers.

The FibraCast hybrid ultrafiltration system is a 0.04 micron PVDF membrane. Each flexible sheet membrane attempts to combine the advantages of hollow-fiber and flat sheet technologies. Each sheet is constructed of nearly 500 fibers and a module consists of 16 triple reinforced sheets potted in a permeate header. The cassette configuration of these modules allows the units to have a very high packing density over a smaller footprint. Similar to the SUEZ hollow fibers, if a sheet were to rip, solids would plug the narrow openings of the fibers that make up a sheet allowing for the membrane to maintain operation and treatment capacity.

SUEZ has numerous installations and demonstrated performance over many years. SUEZ's ZeeWeed hollow fiber systems are in service in over 100 locations throughout the United States, including multiple locations in Michigan (Traverse City, North Kent, Dundee, and Crockery Township). The Koch hollow tube membranes are installed in 16 municipal locations throughout the United States with no facilities currently located in Michigan (the closest installations to Leoni Township are in Pennsylvania and West Virginia). The FibraCast hybrid system has installations in the United States with no facilities currently located in Michigan.

Table 5 provides other key design criteria for the three systems. The major differences between the three manufacturers are:

1. MBR basin modifications: Each option requires fewer tanks than currently being utilized. SUEZ proposes using three of the existing tanks. FibraCast proposes converting two of the existing tanks into three smaller tanks, taking three of the existing tanks out of service. Koch proposes using four of the five existing tanks. For each option the tank bottom would be raised and sloped to assist in collecting and removing grit from the basin.

2. Grit Removal: Of the three systems considered, the SUEZ MBR was the only one for which the existing grit loads are not expected to reduce the useful life of the equipment. For the other manufacturers, upgrading the grit removal system should be given consideration.

3. MBR Blowers (for membrane air scour system): SUEZ has provided a more efficient air scour system for their membranes. The blowers required for their air scour system are significantly smaller than the existing blowers as well as the blowers proposed by the other manufacturers.

| Table 5. Basis of Design Table | | | | |
|---|---|---|---|---|
| | Kubota (Existing) | SUEZ | Koch | FibraCast |
| **Membranes** | | | | |
| Model | RW-400 | ZeeWeed 500D | PURON LE44 | FibrePlate |
| Membrane Configuration | Flat Plate | Hollow Fiber | Hollow Fiber | Hybrid |
| Basins Required | 5 | 3 | 4 | 2 existing, converted into 3 smaller basins |
| Number of Units (Cassettes) | 75 Total (15 each basin) | 18 Total (6 each basin) | 20 Total (5 each basin) | 9 Total (3 each basin) |
| Membrane Area | 6,241 $ft^2$ per cassette | 17,883 $ft^2$ per cassette | 20,451 $ft^2$ per cassette | 42,000 $ft^2$ per cassette |
| Total Membrane Area | 468,075 $ft^2$ | 321,900 $ft^2$ | 409,020 $ft^2$ | 378,000 $ft^2$ |

The Leoni facility has experienced issues (maintenance requirements and noise complaints) with their existing Pre-Aeration and MBR blowers and it is recommended they be replaced as a portion of this project. The facility currently has six blowers, three of which are dedicated to the MBRs. Each alternative includes replacement of all six blowers with positive displacement blowers and sound attenuating enclosures. SUEZ proposes three 60 hp, 1,550 scfm blowers for the membrane air scour system and three (two duty plus one standby) 125 hp, 2,500 scfm blowers for the aeration basins. These blowers would provide enough aeration capacity for both the existing Aeration Basin and the proposed Aeration Basin. Koch recommends replacing the MBR blowers with three 2,227 scfm blowers and replacing the aeration blowers with blowers of the same capacity as the existing (1,736 scfm). Similarly, FibraCast requires three 2,770 scfm blowers for the membrane air scour system and the aeration blowers would be replaced with ones of the same capacity.

Replacement of the existing blowers with positive displacement blowers is being considered for comparison purposes. However, alternative blower technology was also considered to best address the noise and maintenance issues that the plant has experienced. The use of high-speed turbo blowers may be more efficient for the application. High-speed turbo blowers use magnetic fields to levitate the rotor (magnetic bearings) for a 100% non-contact operation. Advantages of this style blower include reduced maintenance demands, increased efficiency, minimal noise, and lubricant free operation. Battery backups supply power to the magnetic bearings in case supply voltage is lost.

Each equipment manufacturer recommends replacing the existing permeate pumps with rotary lobe pumps. Rotary lobe pumps provide the ability to reverse flow for cleaning purposes. The existing flat plate membranes would be damaged if flow was reversed but the hollow tube and hybrid systems can stand up to the pressures associated with backflow. The ability to back pulse the membranes to remove built up sludge assists in cleaning. Rotary lobe pumps also allow the ability to add chemical cleaning agents into the interior of the fibers during manual and recovery cleaning cycles. A dedicated permeate pump with separate header will be used for each train.

## O&M Considerations

Operations and maintenance considerations for each of the systems include cleaning options, energy requirements, and customer support.

The SUEZ system includes four cleaning modes:

- Relax – Permeation is stopped every 10-20 minutes for 30 seconds and aeration is continued while in the wastewater. This is the normal mode.
- Back pulse – Same as relax mode but flow is reversed through the membranes while in the wastewater. No chemicals are added.

- Maintenance Clean – This is an extended backpulse that occurs once per week where bleach is backwashed through the membranes while in the wastewater. This is an unsupervised event and is scheduled for normal low flow periods.
- Recovery Clean – This occurs 1-2 times per year and is an extended ~8 hour soak in a concentrated bleach or a citric acid solution. The tanks are drained of wastewater and refilled with permeate water. Chemicals are added and the soak commences. This is operator initiated based on transmembrane pressures and preference.

The Koch system includes four cleaning modes:

- Relax – An automated procedure designed to remove any accumulated sludge out of the membrane module. It is performed for a short duration (5-10 minutes) immediately prior to the maintenance clean cycle. Permeation is stopped and aeration is continued while in the wastewater.
- Back-flush – Permeate is pumped back through the membranes at low pressure to clean the membrane surface of particles that have accumulated on the surface. The back-flush cycle occurs automatically during the normal process mode cycle, usually lasting less than 30 seconds. No chemicals are added.
- Maintenance Clean – This is a weekly activity that takes 30 minutes to complete. Chemical is backwashed through the membranes while in the wastewater. This is an unsupervised event and is scheduled for normal low flow periods.
- Recovery Clean – This is a yearly activity that takes 8-12 hours to complete. This extended soak in a concentrated bleach or a citric acid solution involves draining the tanks to be refilled with permeate water. Chemicals are added and the soak commences. This is operator initiated based on transmembrane pressures and preference.

The FibraCast system includes three cleaning modes:

- Back pulse – This step of the production cycle is regularly occurring to mitigate solids buildup on the membrane surface. A positive pressure is applied to flow direction is reversed through the membrane and permeate is pushed out. No chemicals are added.
- Maintenance Clean – Maintenance clean involves back pulsing chemical into the membranes and allowing them to soak for a period of time. This normally occurs every 5 to 7 days for approximately 40 minutes.
- Recovery Clean – This occurs 1-2 times per year and is an extended 12 hour soak in a concentrated bleach or a citric acid solution. The tanks are drained of wastewater and refilled with permeate water. Chemicals are added and the soak commences. This is operator initiated based on transmembrane pressures and preference. Chemical is also back pulsed through the membranes.

The additional cleaning modes included in the each system can be thought of as additional tools in the cleaning toolbox compared to existing technology. While these tools are available, they are not required for each cleaning.

Each membrane manufacturer recommends a facility consider replacement after 10 years of operation. Although units can last longer than 10 years, it is not recommended that units be run to failure.

Each manufacturer provides customer support services. The references contacted for each manufacturer were pleased with the customer support they received. Below is a summary of each manufacturer's customer support service. The specific costs associated with the available customer support services need to be verified with the equipment manufacturers.

<u>SUEZ</u>

- 24/7 Telephone support
- InSight cloud-based management (analytics, early detection and alarming, optimization, and reporting)

<u>Koch</u>

- 24/7 Telephone support
- Full remote monitoring with weekly service recommendation reports

<u>FibraCast</u>

- 24/7 Telephone support
- Remote SCADA monitoring and support

## 3.6 Disinfection Facilities

Membrane permeate can be pumped to UV disinfection by the permeate pumps or allowed to flow by gravity. Disinfection is accomplished with two ultraviolet disinfection units in-line prior to cascade aeration. The existing units operate in parallel to provide firm disinfection capacity for and average daily flow of 3.0 mgd and a peak hour flow of 7.0 mgd.

## 3.7 Outfall

Effluent from UV disinfection flows through cascade aeration prior to the Effluent Pump Station. The Effluent Pump Station is a triplex station which uses a 24-inch forcemain to discharge effluent to Outfall 001 on an unnamed tributary of the Grand River.

## 3.8 Chemical Storage and Feed Facilities

Various chemicals are used at the WWTP for treatment and process cleaning. The chemicals used for treatment include ferric chloride for phosphorus removal and polymer for sludge thickening. One 6,000 gallon tank is provided for bulk storage of ferric chloride and two 330 gallon totes for polymer. Two ferric feed pumps and two polymer blending systems are provided for feeding the chemicals to the process.

Sodium hypochlorite is currently used for cleaning the membranes. The cleaning chemical is stored in drums and ordered on an as needed basis. The existing clean in place (CIP) system could be modified for use with the Koch system. A new CIP system is proposed by SUEZ and FibraCast including feed pumps, controls, and instrumentation, and other ancillary equipment.

## 3.9 Solids Handling Facilities

Solids handling facilities for the WWTP include two WAS pumps, one 190,000 gallon and one 223,000 gallon sludge storage tank, two centrifuge pumps and two centrifuges.

## 3.10 Electrical Improvements

The existing SCADA and controls will be upgraded with this project. An intuitive SCADA system allows operation of the facility to run smoothly and efficiently. Each membrane manufacturer will supply updated controls for operation of their system.

## 3.11 Net Present Worth Analysis

A net present worth analysis was completed to compare the alternatives over a 10-year period. This analysis does not identify the source of funds but compares costs uniformly for each alternative over the 10-year planning period. The present worth is the sum which, if invested now at a given interest rate, would provide the funds required to pay project costs over the 10-year planning period. The total present worth, used to compare the alternatives, is the sum of the initial capital cost plus the present worth of Operation, Maintenance, and Replacement (OM&R) costs minus the present worth of the salvage value at the end of the 10-year planning period.

The initial capital costs include construction, contingency, engineering, and administrative costs. Detailed breakdowns are provided in Appendix C. The OM&R costs include the electrical demand, chemical usage, and labor costs associated with membrane equipment system maintenance activities and assume that the current influent flows and loadings will continue over the 10-year period. The salvage value is calculated at the end of 10 years where portions of the project structures or equipment may have a salvage value, which is determined using straight-line depreciation. The present worth of the 10-year salvage value is then computed using the discount rate. The discount rate used in computing the present worth cost is the rate established by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) and is currently set at 0.2%. The following table provides a summary comparison of the assembled project costs.

| Item | SUEZ (MBR Replacement Only) | SUEZ (with Biological Process Changes) | Koch | FibraCast |
|---|---|---|---|---|
| Total Project Cost (2019): | $8,997,000 | $9,627,000 | $8,720,900 | $9,445,000 |
| Annual OM&R Costs: | $43,000 | $43,000 | $64,500 | $31,000 |
| Present Worth of 10 Yrs of OM&R Costs (1) | $425,000 | $425,000 | $638,000 | $307,000 |
| Total Present Worth: | **$9,422,000** | **$10,052,000** | **$9,358,900** | **$9,752,000** |
| | | | | |
| Salvage Value @ 10 Years | $350,000 | $581,000 | $492,900 | $358,000 |
| Present Worth of Salvage Value (1) | $343,000 | $570,000 | $483,100 | $351,000 |
| **Net Present Worth:** | **$9,072,000** | **$9,471,000** | **$8,866,000** | **$9,394,000** |

(1) Discount Rate of 0.2%, Per FY2019 SRF Project Planning

# 4.0 Summary & Recommendations

## 4.1 Summary

Due to the current condition of the existing membranes and the lack of replacement cassettes readily accessible, it is imperative that the Township plan to replace the membrane equipment system to ensure reliable treatment of wastewater. When considering replacement of the membrane system, projected future flows were considered. Three potential replacement membrane systems were identified, and the plant improvements required for each option were reviewed. For the processes upstream of the membranes, minimal modifications are required at this time for each option. However, both Koch and FibraCast indicated that if improvements are not performed to the grit system, there exists the potential for a shorter membrane life.

Each manufacturer considered is able to provide the same treatment capacity as the current membranes using fewer tanks. Suez proposes using three existing tanks, Koch proposes using four existing tanks, and FibraCast proposes converting two existing tanks into three of smaller volume. For each option, the floor will be raised and sloped to convey the grit that accumulates within the tank to a sump for removal. The unoccupied tanks will be available for future use. Additional major equipment to be replaced with each alternative includes permeate pumps, membrane chemical cleaning equipment, membrane blowers, and the biological process blowers.

The economic analysis performed indicates that Koch has the lowest capital cost but the greatest annual operation and maintenance costs. While FibraCast requires the largest capital expenditure, its annual costs are relatively low. SUEZ falls in the middle of Koch and FibraCast for both capital and annual costs. Overall, Koch has the lowest net present worth.

In addition to reviewing the life cycle costs for each alternative, F&V staff accompanied Township officials to plants with alternative membrane equipment in use. The site tours included two plants operating SUEZ equipment (Dundee WWTP in Dundee, MI, and the PARCC Side Clean Water Plant in Plainfield Charter Township, MI) and one plant operating FibraCast equipment (Delphos WWTP in Delphos, OH). Due to the lack of local plants with Koch equipment, a site visit was not feasible. These meetings provided opportunities to discuss operational performance, maintenance history, and installation challenges with those who are familiar with the equipment other than the suppliers. The information gathered through these visits assisted in determining a recommendation for Leoni WWTP.

Operators at plants with SUEZ equipment installed reported that they were extremely pleased with the performance of the membranes as well as the support received from SUEZ. Dundee WWTP previously operated Kubota membranes like those at the Leoni WWTP and ran into similar challenges as the membranes reached the end of their useful life. Since installing the SUEZ equipment, operators at both the Dundee WWTP and the PARCC Side Clean Water Plant have reported smooth operation of the membrane equipment systems and ease of maintenance. In addition to those plants visited, there are over 70 plants across North America in the municipal sector with a capacity greater than 1.0 MGD operating SUEZ membrane equipment systems. A number of systems have extensive history working with SUEZ/GE dating back decades and many have demonstrated a membrane life greater than 10 years. This has significantly increased confidence in the performance of the equipment.

Similar to the Leoni Township WWTP and Dundee WWTP, the Delphos WWTP previously operated using Kubota membranes. Since switching to FibraCast membranes, the plant has experienced more efficient energy usage and lower costs associated with service and replacement.

## 4.2 Recommended Alternative

It is recommended that the existing membrane technology be replaced to avoid failure of the secondary treatment system at the WWTP. The preferred manufacturer is SUEZ due to the long-term success of its membranes in similar plants, the operational and maintenance requirements, and the customer support available from SUEZ as well as support available from operators of SUEZ equipment at other plants throughout Michigan.

Along with replacing the membrane equipment system, SUEZ proposed an option to modify the biological processes. The proposed changes include adding aeration to the existing anoxic zone. This would provide the benefit of increasing reliability of the membranes by separating the biological treatment from the ultrafiltration. Because these proposed changes do not directly impact the design or implementation of the membrane equipment itself, these improvements may be implemented in the future as flows and loadings change. However, it is recommended that the Township budget for these changes at the same time as the membrane replacement.

A Part 41 Construction Permit will be required prior to replacement of the existing MBR equipment. The time required for review and approval from EGLE is considered in the implementation schedule presented in Section 4.4.

## 4.3 Financing

Available options for funding this project include municipal bonds and the Clean Water State Revolving Fund (SRF). A municipal financial advisor should be consulted to determine the best source of funding for the project.

Issuing municipal bonds is one option to finance wastewater system projects. The municipal bond rate is dependent on the loan term and the Township's credit rating. Financing the project with municipal bonds does not put restrictions on the project schedule, project delivery methods, or bidding requirements. However, the interest rate would be higher than funding through the SRF program.

Financing through the SRF program is another option for consideration. The SRF program is a federal-state partnership that provides communities a permanent, independent source of low-cost financing for a wide range of water quality infrastructure projects. The current interest rate for SRF loans is 2.0% for 20-year loans in fiscal year 2020. Financing the project through the SRF program requires a project plan to be completed to qualify for funding. The feasibility study can be used as a basis for the project plan. The SRF program requires following a quarterly schedule for design and bidding of projects and limits project delivery methods. The SRF program also requires compliance with Davis-Bacon prevailing wage rates for labor and compliance with American Iron and Steel requirements which may increase construction costs.

## 4.4 Implementation Schedule

The anticipated project schedule includes consideration for design, permitting, bidding, and construction. This schedule assumes that the project financing is secured prior to proceeding with design. The anticipated schedule is based on the issue of a Notice to Proceed (NTP) with design, as follows:

| Project Phase | Period Following NTP |
|---|---|
| Design | 6 – 8 months |
| Permitting | 12 months |
| Bidding & Contracting | 14 months |
| Construction & Commissioning | 24 – 30 months |

# APPENDIX A

## Basis of Design

# Leoni Township WWTP
## MBR Basis of Design Summary

**Date:** Updated July 23, 2019
**Type of Treatment:** Membrane Bioreactor

### Existing MBR Basis of Design

| | | |
|---|---|---|
| Maximum Monthly Flow: | 3 | mgd |
| Peak Daily Flow: | 4.8 | mgd |
| Frequency of Peak Daily Flow Events: | 10 | per year |
| Peak Instantaneous Flow: | 8 | mgd |

Average Influent Wastewater Characteristics:

| | | |
|---|---|---|
| BOD: | 8,081 | lb/d |
| TSS: | 9,207 | lb/d |
| Ammonia: | 1,051 | lb/d |
| TKN: | 1,476 | lb/d |
| Alkalinity: | 7,506 | lb/d |
| FOG: | <35 | mg/L |
| pH: | 6-8 | SU |

| | | |
|---|---|---|
| Average influent water temperature: | 10-20 | ˚C |
| Ambient air temperature: | 5-60 | ˚C |

| | | |
|---|---|---|
| MLSS at design loading conditions: | 10,000 | mg/L |
| Allowable MLSS operating range: | 8,000-18,000 | mg/L |

Primary Process Design Parameters:

| | | |
|---|---|---|
| SRT: | >25 | d |
| Yield: | 0.75 | lb/lb |
| Fine Bubble Alpha: | 0.69 | |
| Fine Bubble OTE: | 2 | %/ft |
| Coarse Bubble Alpha: | 0.765 | |
| Coarse Bubble OTE: | 0.5 | |
| Maximum OUR: | 100 | mg/L/hr |

Average Effluent Quality (monthly average of at least four 24-hr composite samples):

| | | |
|---|---|---|
| BOD: | <4 | mg/L |
| Ammonia: | <0.5 | mg/L |
| TSS: | <20 | mg/L |

### Current WWTP Flows and Loadings:

| | | |
|---|---|---|
| 2019 Population Served: | 27,272 | |
| Average Daily Flow (ADF): | 1.73 | MGD |
| Maximum Daily Flow: | 3.56 | MGD |
| Maximum Monthly Flow: | 2.38 | MGD |

Current Influent Sewage Characteristics (2017-2019):

| | Average | | Max Month | Max Day |
|---|---|---|---|---|
| | mg/L | lbs/day | lbs/day | lbs/day |
| BOD: | 263 | 3,697 | 4,732 | 9,133 |
| TSS: | 430 | 6,037 | 8,039 | 24,794 |
| Phosphorus: | 8.2 | 116 | 164 | 526 |
| Ammonia: | 36.4 | 519 | 688 | 1,492 |

### NPDES Effluent Limitations

| Effluent Parameter | Maximum Loading (lb/d) | | | Maximum Concentration (mg/L) | | |
|---|---|---|---|---|---|---|
| | Monthly | 7-Day | Daily | Monthly | 7-Day | Daily |
| $CBOD_5$ | | | | | | |
| May-November | 100 | 250 | (report) | 4 | --- | 10 |
| December-March | 580 | 850 | (report) | 23 | --- | 34 |
| April | 600 | 900 | (report) | 24 | --- | 36 |
| Total Suspended Solids | | | | | | |
| May-November | 500 | 750 | (report) | 20 | 30 | (report) |
| Decmber-April | 750 | 1100 | (report) | 30 | 45 | (report) |
| Ammonia Nitrogen | | | | | | |
| May-November | 13 | 50 | (report) | 0.5 | --- | 2 |
| December-March | 290 | 430 | (report) | 11.4 | --- | 17 |
| April | 330 | 380 | (report) | 13.3 | --- | 15 |
| Total Phosphorus | 8.3 | --- | (report) | 0.33 | --- | (report) |

## Headworks (Existing):

Wastewater enters the faclity through a 24" forcemain.

**Septage Receiving**

| | | |
|---|---|---|
| Holding Tank: | 50000 | gal |
| Pump Station: | | |

**Equipment**

Fine Screen

| | | |
|---|---|---|
| Quantity: | 2 | |
| Manufacturer: | Huber - Perforated Plate | |
| Model: | RPPS/1600/3 | |
| Openings: | 1/8 | in |
| Peak Daily Flow: | 6 | MGD, per screen |
| Max Flow: | 8.5 | MGD, per screen |
| Power: | 2.00 | hp |

Grit Removal

| | | |
|---|---|---|
| Quantity: | 1 | |
| Type: | Vortex | |
| Manufacturer: | Waste Tech | |
| Model: | XGT Model 425 | |
| Average Flow Rate: | 3.0 | MGD |
| Peak Flow Rate: | 8.5 | MGD |
| Power: | 5 | hp |

Grit Classifier

| | | |
|---|---|---|
| Quantity: | 1 | |
| Manufacturer: | Waste Tech | |
| Model: | KZC-230 | |
| Hydraulic Capacity: | 200 | gpm |
| Power: | 3/4 | hp |

## Anaerobic Basin (Existing):

**Basin Dimensions**

Anaerobic Basin

| | | |
|---|---|---|
| Quantity: | 3 | |
| Length: | 13 | ft |
| Width: | 40.5 | ft |
| Side Water Depth: | 16.67 | ft |
| Volume per Tank: | 65,650 | gallons, each |
| Volume Total: | 196,950 | gallons |
| | | |
| Detention Time: | 2.7 | hr retention time at ADF |
| | 1.6 | hr retention time at MMF |

Mixer

| | | |
|---|---|---|
| Quantity: | 3 | |
| Manufacturer: | WILO-EMU USA LLC | |
| Model: | TE 60- 27-6/8 R | |
| Min Flow Circulation Cap: | 7,606 | gpm |
| Max Power | 2.68 | hp |

## Pre-Anoxic Basin (Existing):

**Basin Dimensions**

Pre-Anoxic Basin

| | | |
|---|---|---|
| Quantity: | 3 | |
| Length: | 57.7 | ft |
| Width: | 40.5 | ft |
| Side Water Depth: | 15 | ft |
| Volume per Tank: | 262,043 | gallons, each |
| Volume Total: | 786,129 | gallons |
| | | |
| Detention Time: | 10.9 | hr retention time at ADF |
| | 6.3 | hr retention time at MMF |

**Equipment**

Feed Forward Pumps

| | | |
|---|---|---|
| Type: | Submersible | |
| Quantity: | 6 | |
| Manufacturer: | ABS | |
| Model: | AFP 3003 ME70/8 | |
| Capacity: | 3646 | gpm, each |
| Head: | 16.8 | ft TDH |
| Capacity: | 1600 | gpm, each |
| Head: | 26 | ft TDH |
| Power: | 22.8 | hp |

Mixer

| | | |
|---|---|---|
| Quantity: | 3 | |
| Manufacturer: | Wilco-EMU | |
| Model: | T 17-4/8REx | |
| Min Flow Circulation Capacity: | 17748 | gpm |
| Max Power : | 5.6 | hp |

## Pre-Aeration Basins (Existing):

**Basin Dimensions**

Pre-Aeration Basins

| | | |
|---|---|---|
| Quantity: | 3 | |
| Length: | 58.3 | ft |
| Width: | 40.5 | ft |
| Side Water Depth: | 17.09 | ft |
| Volume per Tank: | 302,006 | gallons, each |
| Volume Total: | 906,018 | gallons |
| | | |
| Detention Time: | 12.5 | hr retention time at ADF |
| | 7.2 | hr retention time at MMF |

**Equipment**

Pre-Aeration Mixers:

Mixer

| | | |
|---|---|---|
| Quantity: | 3 | |
| Manufacturer: | Wilco-EMU | |
| Model: | T 17-4/8REx | |
| Min Flow Circulation Capacity: | 17748 | gpm |
| Max Power: | 5.6 | hp |

Internal Recycle Pumps

| | | |
|---|---|---|
| Quantity: | 3 | |
| Manufacturer: | ABS | |
| Model: | AFP 1546 ME35/6 | |
| Capacity: | 1218 | gpm, each |
| Head: | 8 | ft TDH |
| Capacity: | 400 | gpm, each |
| Head: | 24 | ft TDH |
| Power: | 4.7 | hp |

Diffusers

| | | |
|---|---|---|
| Quantity: | 828 | per basin |
| | 2484 | total |
| Manufacturer: | Sanitaire | |
| | | |
| Std O2 Transfer Rate: | 32760 | lb $O_2$/d |
| Volumetric Air Rate: | 4000 | scfm |
| Operating Pressure: | 7.6 | psig |
| Diffuser Sumergence: | 15.9 | ft |

| **Pre-Aeration Basins (Existing):** | | |
|---|---|---|
| Pre-Aeration Blowers | | |
| Quantity: | 2 | |
| Manufacturer: | ROOTS EasyAir X2 | |
| Model: | 155 - 500 RAM X | |
| Discharge Pressure: | 8.5 | psi |
| Inlet Capacity: | 1736 | acfm |
| Motor Size: | 100 | hp |

| **MBR Basins (Existing):** | | |
|---|---|---|
| **Basin Dimensions** | | |
| MBR Basins | | |
| Quantity: | 5 | |
| Width: | 14 | ft |
| Length: | 51 | ft |
| Height: | 20 | ft |
| Max Water Level: | 16 | ft |
| Area: | 714 | $ft^2$ per tank |
| | 3570 | $ft^2$ total |
| Working Volume: | 11,467 | $ft^3$ per tank |
| | 85,772 | gal per tank |
| | 428,860 | gal total |
| **Equipment** | | |
| Membrane Filtration | | |
| Number: | 5 | |
| Manufacturer: | Enviroquip - Kubota | |
| Model: | RW-400 | |
| No. of Cartridges: | 400 | |
| Effective Membrane Area: | 6241 | $ft^2$ |
| Initial Flow Rate: | 177 | gpm |
| Permeate Pumps | | |
| Quantity: | 5 | |
| Manufacturer: | Gorman Rupp | |
| Type: | Horizontal Self-Priming Centrifugal | |
| Model: | Super T-Series (T8A60S-B) | |
| Capacity: | 1235 | gpm, each |
| Head: | 30.5 | ft TDH |
| Power: | 15 | hp |

| MBR Basins (Existing): | | |
|---|---|---|
| Quantity: | 4 | |
| Manufacturer: | ROOTS EasyAir X2 | |
| Model: | 155 - 500 RAM X | |
| Discharge Pressure: | 7.5 | psi |
| Inlet Capacity: | 2374 | acfm |
| Motor Size: | 125 | hp |

| Cascade Aeration and Effluent Pump Station (Existing): | | |
|---|---|---|
| **Cascade Aeration** | | |
| Dimensions | | |
| Channel Width: | 18 | ft |
| Tread Length: | 2 | ft |
| Riser Height: | 1 | ft |
| No. Steps: | 12 | |
| **Effluent Pump Station** | | |
| Effluent Pumps | | |
| Quantity: | 3 | |
| Type: | Vertical Turbine | |
| Manufacturer: | Goulds | |
| Model: | Model VIT-FUTM size 14 RHMO | |
| Capacity: | 2440 | gpm, each |
| Head: | 72 | ft TDH |
| Power: | 60 | hp |

## UV Disinfection (Existing):

**Equipment**

| | | |
|---|---|---|
| Number: | 2 | banks |
| Manufacturer: | Trojan Technologies | |
| Model: | UV 3000 Plus | |
| | | |
| No. Modules: | 4 | per bank |
| Channel width: | 2 | ft |
| UV bank width: | 1.5 | ft |
| Bank length: | 8.2 | ft |
| | | |
| Design Average Flow: | 3.0 | mgd |
| Peak Hour Flow: | 7.0 | mgd |
| | | |
| Max Influent TSS: | 30 | mg/L |
| UV Dose: | 30000 | uW*s/cm2 |
| UV Trans (at 253.7 nm): | 75 | % min |

## Solids Handling

**Dimensions**

Sludge Storage Tanks

| | | |
|---|---|---|
| Quantity: | 2 | |
| Diameter 1: | 36 | ft |
| Diameter 2: | 39 | ft |
| Side Water Depth: | 25 | ft |
| Volume 1: | 25,447 | gallons |
| Volume 2: | 29,865 | gallons |
| Volume Total: | 55,312 | gallons |

**Equipment**

Decanter

| | | |
|---|---|---|
| Quantity: | 2 | |
| Manufacturer: | Hamlett Environmental | |
| Model: | Model SWS-300 | |
| Max Flow Rate: | 300 | gpm |
| Draw Off Depth: | 4-8 | in |

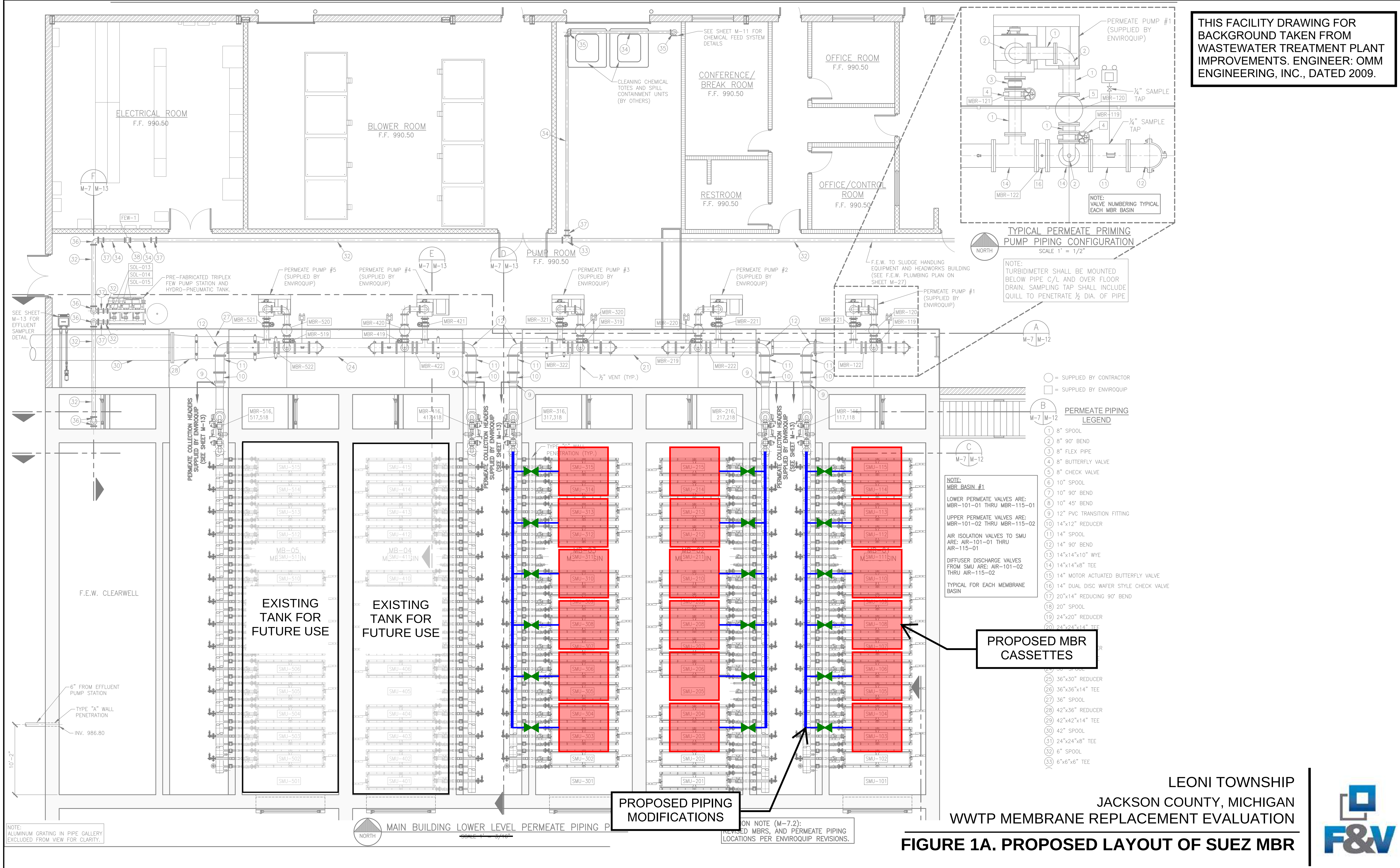
Chopper/Mixing Pump

| | | |
|---|---|---|
| Quantity: | 1 | |
| Type: | Horizontal Self Priming Centrifugal | |
| Capacity: | 680 | gpm, each |
| Head: | 40 | ft TDH |
| Power: | 15 | hp |

| Solids Handling | | |
|---|---|---|
| Quantity: | 2 | |
| Manufacturer: | Gorman Rupp | |
| Model: | Super T-Series (T3A60S-B) | |
| Capacity: | 175 | gpm, each |
| Head: | 33 | ft TDH |
| Power: | 5 | hp |
| | | |
| Centrifuge Pumps | | |
| Quantity: | 2 | |
| Type: | Positive displacement, progress cavity | |
| Manufacturer: | Moyno | |
| Model: | Model 2000 Series | |
| Capacity: | 300 | gpm, each |
| Head: | 30 | ft TDH |
| Power: | 15 | hp |
| | | |
| Centrate Pumps | | |
| Quantity: | 2 | |
| Capacity: | 750 | gpm, each |
| Head: | 25 | ft TDH |
| Power: | 10 | hp |
| | | |
| Centrifuges | | |
| Quantity: | 2 | |
| Manufacturer: | Westfalia Separator | |
| Sludge Feed Rate: | 245 | gpm |
| Dry Solids Feed Rate: | 1716 | lb/hr |
| Minimum Cake Solids: | 18 | % |

## APPENDIX B

## Proposed Layouts from Equipment Manufacturers

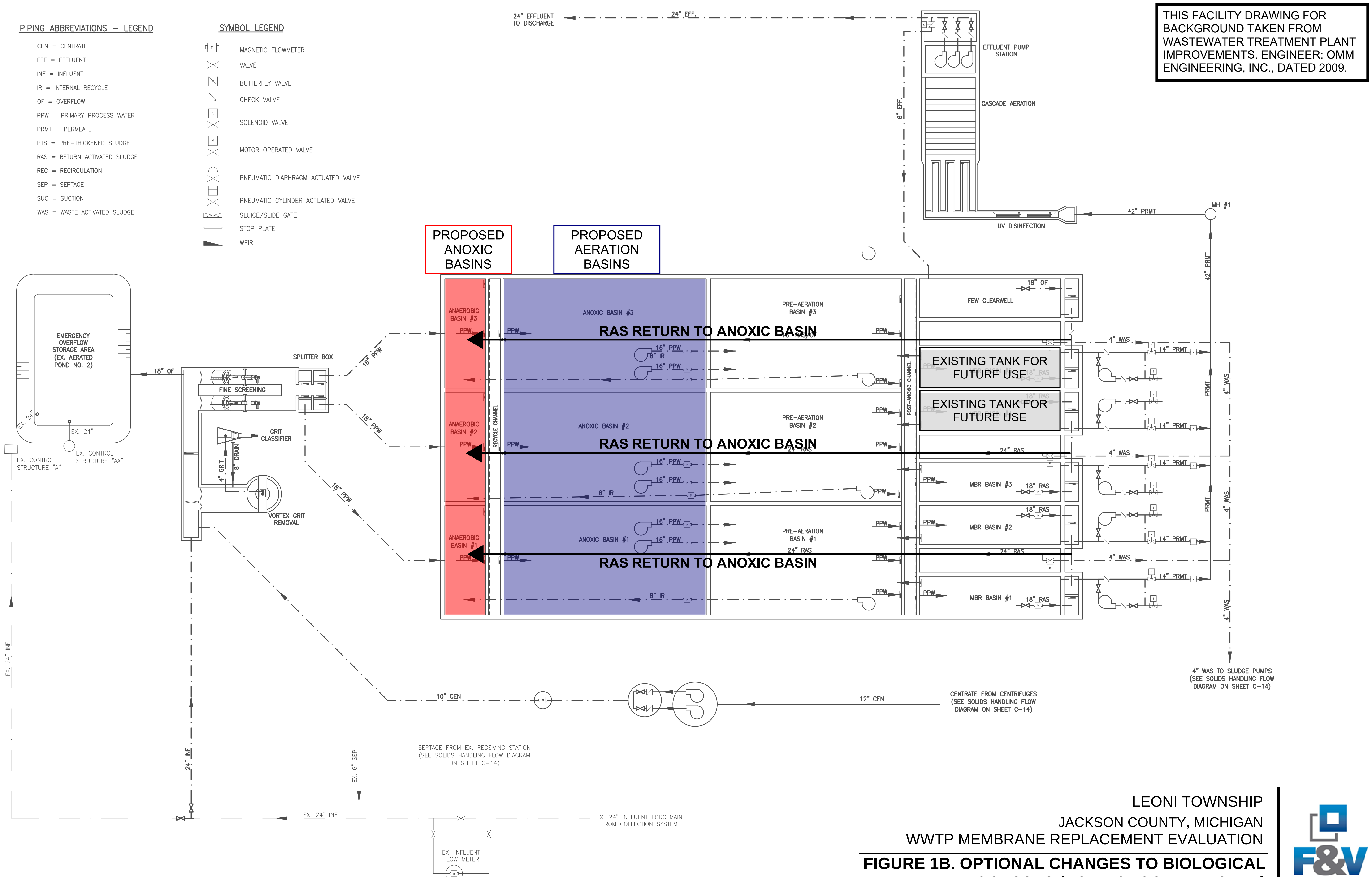



LEONI TOWNSHIP

JACKSON COUNTY, MICHIGAN

WWTP MEMBRANE REPLACEMENT EVALUATION

**FIGURE 1A. PROPOSED LAYOUT OF SUEZ MBR**



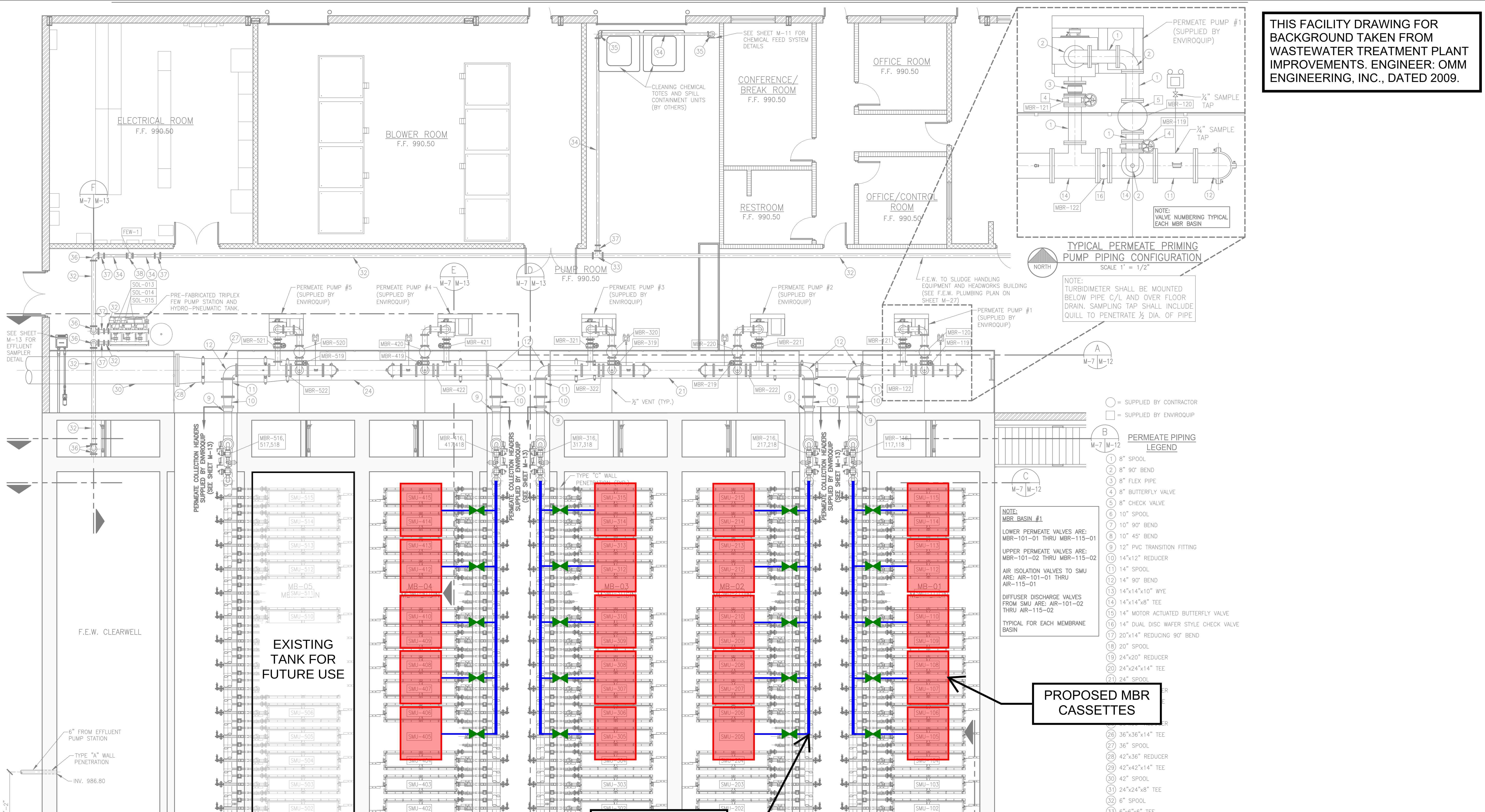

LEONI TOWNSHIP

JACKSON COUNTY, MICHIGAN

WWTP MEMBRANE REPLACEMENT EVALUATION

**FIGURE 1B. OPTIONAL CHANGES TO BIOLOGICAL TREATMENT PROCESSES (AS PROPOSED BY SUEZ)**

F&V

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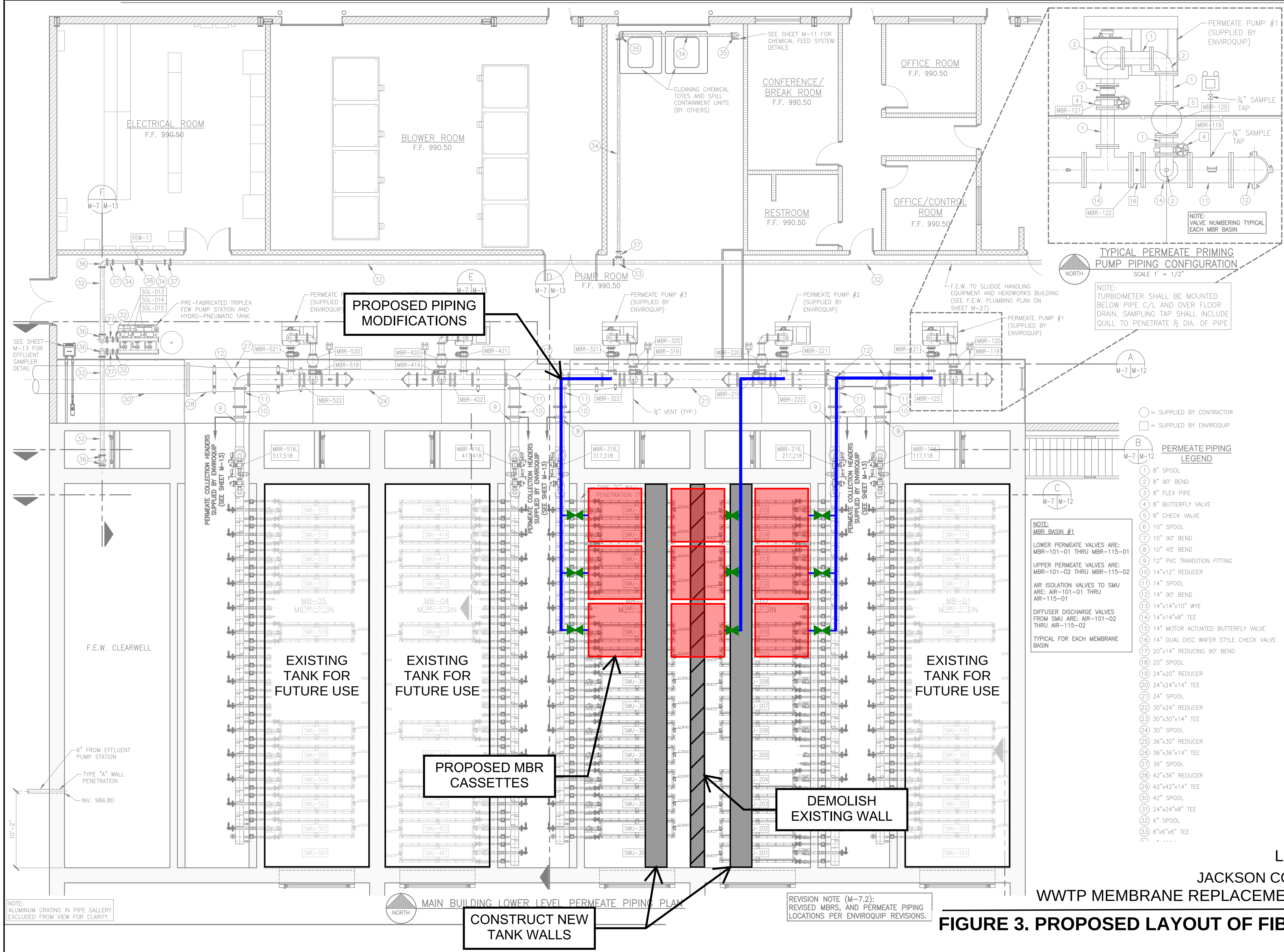
JACKSON COUNTY, MICHIGAN

WWTP MEMBRANE REPLACEMENT EVALUATION

**FIGURE 2. PROPOSED LAYOUT OF KOCH MBR**

THIS FACILITY DRAWING FOR BACKGROUND TAKEN FROM WASTEWATER TREATMENT PLANT IMPROVEMENTS. ENGINEER: OMM ENGINEERING, INC., DATED 2009.

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JACKSON COUNTY, MICHIGAN

WWTP MEMBRANE REPLACEMENT EVALUATION

**FIGURE 3. PROPOSED LAYOUT OF FIBRACAST MBR**

# APPENDIX C

## Engineer's Opinion of Probable Project Cost

FLEIS&VANDENBRINK
DESIGN. BUILD. OPERATE.

## Engineer's Opinion of Probable Project Cost [1]

| | | | |
|---|---|---|---|
| *Project:* | Leoni Township - MBR Evaluation | *Project No.* | 840610 |
| *Basis for Estimate:* | [ X ] Conceptual [ ] Basis of Design [ ] Final | *Estimator:* | SPP |
| *Work:* | **SUEZ ZeeWeed Membrane System** | *Date:* | 11/11/2019 |
| | | *Current ENR-CCI:* | 11293 |

| Item | Description | Unit | Qty. | Unit Price | Amount |
|---|---|---|---|---|---|
| 1 | Concrete | LS | 1 | $146,000 | $146,000 |
| 2 | General Trades | LS | 1 | $121,000 | $121,000 |
| 3 | Painting | LS | 1 | $50,000 | $50,000 |
| 4 | Mechanical | LS | 1 | $4,869,000 | $4,869,000 |
| 5 | Electrical | LS | 1 | $261,000 | $261,000 |
| 6 | General Conditions and OH&P | | 18% | | $980,000 |
| | | | | **Construction Total:** | **$6,427,000** |
| 7 | Construction Contingency and Undeveloped Details | | 20% | | $1,285,000 |
| 8 | Engineering & Administration | | 20% | | $1,285,000 |
| | | | | **Total Project Cost:** | **$8,997,000** |

Notes:

(1) This estimate represents a budgetary cost estimate to be used for planning purposes. Further definition of the scope of the project through preliminary and final design will provide details necessary to improve the accuracy of conceptual estimates.

FLEIS&VANDENBRINK
DESIGN. BUILD. OPERATE.

# Engineer's Opinion of Probable Project Cost [(1)]

| | | | |
|---|---|---|---|
| *Project:* | Leoni Township - MBR Evaluation | *Project No.* | 840610 |
| *Basis for Estimate:* | [ X ] Conceptual [ ] Basis of Design [ ] Final | *Estimator:* | SPP |
| *Work:* | **SUEZ ZeeWeed Membrane System** | *Date:* | 11/8/2019 |
| | *Includes changes to biological treatment processes* | *Current ENR-CCI:* | 11293 |

| Item | Description | Unit | Qty. | Unit Price | Amount |
|---|---|---|---|---|---|
| 1 | Concrete | LS | 1 | $226,000 | $226,000 |
| 2 | General Trades | LS | 1 | $121,000 | $121,000 |
| 3 | Painting | LS | 1 | $50,000 | $50,000 |
| 4 | Mechanical | LS | 1 | $5,157,000 | $5,157,000 |
| 5 | Electrical | LS | 1 | $274,000 | $274,000 |
| 6 | General Conditions and OH&P | | 18% | | $1,049,000 |
| | | | | **Construction Total:** | **$6,877,000** |
| 7 | Construction Contingency and Undeveloped Details | | 20% | | $1,375,000 |
| 8 | Engineering & Administration | | 20% | | $1,375,000 |
| | | | | **Total Project Cost:** | **$9,627,000** |

Notes:

(1) This estimate represents a budgetary cost estimate to be used for planning purposes. Further definition of the scope of the project through preliminary and final design will provide details necessary to improve the accuracy of conceptual estimates.

FLEIS&VANDENBRINK
DESIGN. BUILD. OPERATE.

# Engineer's Opinion of Probable Project Cost [1]

| | | | |
|---|---|---|---|
| *Project:* | Leoni Township - MBR Evaluation | *Project No.* | 840610 |
| *Basis for Estimate:* | [ X ] Conceptual [ ] Basis of Design [ ] Final | *Estimator:* | SPP |
| *Work:* | **Koch Puron Membrane System** | *Date:* | 11/11/2019 |
| | | *Current ENR-CCI:* | 11293 |

| Item | Description | Unit | Qty. | Unit Price | Amount |
|---|---|---|---|---|---|
| 1 | Concrete | LS | 1 | $132,000 | $132,000 |
| 2 | General Trades | LS | 1 | $161,700 | $161,700 |
| 3 | Painting | LS | 1 | $50,000 | $50,000 |
| 4 | Mechanical | LS | 1 | $4,352,000 | $4,352,000 |
| 5 | Electrical and I&C | LS | 1 | $583,000 | $583,000 |
| | | | | | |
| 6 | General Conditions and OH&P | | 18% | | $950,200 |
| | | | | **Construction Total:** | **$6,228,900** |
| | | | | | |
| 7 | Construction Contingency and Undeveloped Details | | 20% | | $1,246,000 |
| 8 | Engineering & Administration | | 20% | | $1,246,000 |
| | | | | | |
| | | | | **Total Project Cost:** | **$8,720,900** |

Notes:

(1) This estimate represents a budgetary cost estimate to be used for planning purposes. Further definition of the scope of the project through preliminary and final design will provide details necessary to improve the accuracy of conceptual estimates.

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# Engineer's Opinion of Probable Project Cost [1]

| | | | |
|---|---|---|---|
| *Project:* | Leoni Township - MBR Evaluation | *Project No.* | 840610 |
| *Basis for Estimate:* | [ X ] Conceptual [ ] Basis of Design [ ] Final | *Estimator:* | SPP |
| *Work:* | **Fibracast FibrePlate Membrane System** | *Date:* | 11/11/2019 |
| | | *Current ENR-CCI:* | 11293 |

| Item | Description | Unit | Qty. | Unit Price | Amount |
|---|---|---|---|---|---|
| | | | | | |
| 1 | Concrete | LS | 1 | $150,000 | $150,000 |
| 2 | General Trades | LS | 1 | $50,000 | $50,000 |
| 3 | Painting | LS | 1 | $50,000 | $50,000 |
| 4 | Mechanical | LS | 1 | $5,244,000 | $5,244,000 |
| 5 | Electrical and I&C | LS | 1 | $224,000 | $224,000 |
| | | | | | |
| | | | | | |
| 6 | General Conditions and OH&P | | 18% | | $1,029,000 |
| | | | | **Construction Total:** | **$6,747,000** |
| | | | | | |
| 7 | Construction Contingency and Undeveloped Details | | 20% | | $1,349,000 |
| 8 | Engineering & Administration | | 20% | | $1,349,000 |
| | | | | | |
| | | | | **Total Project Cost:** | **$9,445,000** |

Notes:

(1) This estimate represents a budgetary cost estimate to be used for planning purposes. Further definition of the scope of the project through preliminary and final design will provide details necessary to improve the accuracy of conceptual estimates.