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Memorandum

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Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Facilities Engineering – Preliminary Design Report (25% Design) Downtown Area** **Task 10.1.C.5 - Update WWTF Process Selection**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
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Approvals	Date	Signature / Initials
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1. Introduction

In addition to evaluating "non-traditional" technologies, a component of the Water Quality and Planning effort currently on-going with the Town of Orleans (Town) includes evaluating conventional treatment options to address areas of the town where non-traditional technologies would not be sufficient to address water quality, regulatory, economic development and other needs. Previous evaluations have identified the Downtown Area commercial district as well as the residential area in the vicinity of Meetinghouse Pond Area as two areas of town where conventional wastewater treatment is the appropriate solution to the Town's requirements.

Even under the banner of conventional wastewater treatment, there is a broad range of technology options available. This Technical Memorandum (TM) identifies the design basis for the treatment facility, evaluates various unit processes, recommends technologies for selection, and presents preliminary design information. While initially intended to be part of this TM, the discussion of collection system design and treated effluent conveyance and disposal has been addressed under separate cover.

2. Flows and Loading

A. Initial and Design Flows and Loadings

The Orleans WWTF is proposed to be constructed in two phases. The first phase will accommodate half of the Downtown Area (Phase 1 and Phase 2 of the collection system) and half of the Meetinghouse Pond Area (Phase 1 of the collection system) with associated infiltration/inflow (I/I), as well as septage receiving. The second phase will accommodate the capacity requirements for the remainder of the Downtown Area (Phase 3 and Phase 4 of the collection system) and Meetinghouse Pond Area (Phase 2 of the collection system). The second phase would be scheduled for construction approximately 10 to 15 years after the first phase. While this preliminary design report focuses on the design of Phase 1 of the WWTF, the design concept incorporates some features intended to accommodate both Phases, where it makes sense from a construction cost standpoint to do so. This will be discussed in further detail later on in this Technical Memorandum.

In order to estimate the existing wastewater flows, a 95 percent factor was applied to the 2014 and 2015 water usage data.

- Future wastewater flows for the Downtown Area were predicted based on a preferred build-out scenario previously evaluated for the Town, as summarized in the *Final Memorandum on Management of Future Downtown Wastewater Flows and Biosolids* (May 2016).
- Future wastewater flows for the Meetinghouse Pond Area were predicted based on current zoning regulations. These future flows were used to develop the design annual average wastewater flow to the WWTF.
- Infiltration/Inflow flows were developed based on TR-16 - Guides for the Design of Wastewater Treatment Works, (2011 Edition as Revised in 2016) by the New England Interstate Water Pollution Control Commission. An allowance was added to the future wastewater flows to account for the normal aging of piping systems based on 300 gpd/in. diameter/mile of gravity sewer with an average gravity pipe diameter of 10-inches.

Even after the completion of a sewage collection and transmission system for these two areas, there will still be a significant amount of properties in Town that continue to rely on septic systems. In addition, there will continue to be a need for septage disposal capacity to service the surrounding communities in the lower/outer Cape. Based on a previous study[1], the former Tri-Town Septage Treatment Facility averaged in the order of 9 million gallons of septage annually over the past several years. The sewering of some parts of the Town will obviously decrease septage generation within Orleans. In addition, some permanent loss of market might be expected from some of the communities proximate to the Yarmouth-Dennis facility, as it expands operations to fill the void left by the closure of the Tri-Town Septage Treatment Facility. AECOM has conservatively prorated the Tri-Town Septage Treatment Facility receiving rates on a town by town basis to what they might be expected to be in the future and has arrived at a projected “high-end” septage loading of 6 million gallons annually, or 16,000 gal/d. While this rate will depend on how the Town chooses to operate the proposed Overland Way WWTF, this is considered a reasonable assumption with which to estimate loadings to the facility.

Table 1 summarizes the future build-out flows used for the design basis of the WWTF.

[1] AECOM. Cape Cod Commission 208 Water Quality Management Plan Update Task Order 12D – *Technical Memorandum on Barnstable County Septage Analysis*. June, 2016.

Table 1: WWTF Annual Average Flow

Area	Future Wastewater Flow (with Build-out) Annual Average (gpd)
WWTF – Phase 1	**186,300**
Downtown – Phase 1	59,300
Downtown – Phase 2	50,300
Meetinghouse Pond-Phase 1	48,300
Downtown I/I (Phases 1 and 2)	8,400
Meetinghouse Pond I/I (Phase 1)	4,000
Septage	16,000
WWTF Total – Phase 1	**163,200**
WWTF – Phase 2	
Downtown – Phase 3	76,100
Downtown – Phase 4	26,400
Meetinghouse Pond-Phase 2	48,300
Downtown I/I (Phases 3 and 4)	8,400
Meetinghouse Pond I/I (Phase 2)	4,000
WWTF Total -Phase 1 + Phase 2	**349,500**

In order to estimate the minimum and maximum hourly, daily, and monthly flows, data from treatment plants in Falmouth, Chatham, and Provincetown were reviewed and compared to literature values. It was assumed that the Town of Chatham is most similar to the Town of Orleans due to its close proximity and similar demographic. Peaking factors developed from Chatham's historical operating data were very similar to peaking factors found in the literature[2] for the minimum and maximum month conditions, which are important in the development of the biological treatment system design. Peaking factors for the more extreme max/min day and hour conditions were dampened in the Chatham data compared to literature values, however max day peaking factors similar to literature values were seen at Provincetown. It was therefore concluded that defaulting to literature guidelines was the appropriate course and the literature peaking factors were used to generate minimum and maximum hourly, daily, and monthly flows for use in the design of the Orleans WWTF. The peaking factor comparison and selection is shown in Table 2.

[2] "TR-16, Guides for the Design of Wastewater Treatment Works", New England Interstate Water Pollution Control Commission, 2011. "Wastewater Engineering, Treatment and Resource Recovery", Metcalf & Eddy, 5th ed.

Table 2: Peaking Factor Selection

	Min Hour: AA	Min Day: AA	Min Month: AA	Max Month: AA	Max Day: AA	Max Hour: AA
Falmouth	---	0.65	0.80	1.3	1.8	---
Provincetown	---	0.36	0.45	2.1	2.6	---
Chatham	---	0.54	0.75	1.4	1.9	---
Literature Values	---	0.38	0.85	1.4	2.7	---
Design	0.17	0.36	0.85	1.4	2.8	5

The design flows were determined by applying the selected peaking factors from Table 2 on the Phase 1 annual average flow of 186,300 gpd. As important as flow projections however, an estimate of pollutant mass loadings is required to properly size WWTFs. Because there is no existing sewage collection or treatment system in place, there is no data from which to project sewage pollutant concentrations. Normal textbook[3] ranges for the key parameters of BOD, TKN and TSS are as shown in Table 3 below. To reflect the fact that this will be a new collection system where ingress/infiltration will be low, the concentrations were assumed to be on the medium to higher end of the range.

Table 3: Assumed Sewage Pollutant Concentrations

	Typical Ranges			
Constituent	Low	Medium	High	Value Assumed
BOD, mg/l	110	190	350	270
TKN, mg/l	20	40	70	55
TSS, mg/l	120	210	400	310

To address what impact septage receiving would have, actual annual average data from the former Tri-Town Septage Treatment Facility was used. It was assumed that septage will be processed with biosolids from the facility, so that only septage filtrate would be mixed with raw sewage influent to reduce solids loadings on the biological process. A flow weighted average of the sewage and septage filtrate characteristics, in combination with the design annual average flow, was used to define annual average pollutant loadings. Similar to flows, max month and max day pollutant loadings were prorated off of annual average loadings based on peaking factors derived from TR-16 - Guides for the Design of Wastewater Treatment Works, (2011 Edition as Revised in 2016) by the New England Interstate Water Pollution Control Commission. Note that the annual average, max month, and max day loading are the only conditions considered relevant to the design of the biological process. The more extreme conditions of flow are considered for hydraulic capacity reasons only.

[3] "Wastewater Engineering, Treatment and Reuse", Metcalf & Eddy, 4th ed.

Table 4: WWTF Phase 1 Design Flow and Loadings

	Min Hour	Min Day	Min Month	Annual Average	Max Month	Max Day	Peak Hour[1]
Flow, gpd	31,700	67,100	158,400	186,300	260,800	521,600	931,500
BOD, lb/d	---	---	---	428	539	685	---
TSS, lb/d	---	---	---	466	606	886	---
TKN, lb/d	---	---	---	94	117	132	---

B. Anticipated Permit Limits

The Orleans WWTF will be regulated by the Massachusetts Department of Environmental Protection (MassDEP) under its Bureau of Resource Protection's Division of Water Pollution Control. The Massachusetts Groundwater Discharge Permit Program (314 CMR 5.00), requires any person who discharges, or proposes to discharge, pollutants to the groundwaters of the Commonwealth to obtain a discharge permit pursuant to G.L. c.21 s.43.

The permitted wastewater treatment facility must be operated by a Certified Wastewater Treatment Plant Operator in accordance with the "Rules and Regulations for Certification of Operators of Wastewater Treatment Facilities" (257 CMR 2.00). The permit holder bears the ultimate responsibility of providing for the proper operation and maintenance of the facilities in accordance with "Operation and Maintenance and Pretreatment Standards for Wastewater Treatment Works and Indirect Discharges" (314 CMR 12.00). The anticipated limits of the Orleans WWTF are summarized in Table 5.

Table 5: Anticipated Effluent Permit Limits

Constituent	Anticipated Effluent Limit
BOD, mg/L	30
TSS, mg/L	30
TN, mg/L	10
Fecal Coliform, cfu/100 mL	200

3. Review of Process Equipment and Tankage Options

The following sections document key considerations and assumptions for the recommended preliminary design of the WWTF. Various manufacturer quotes were obtained and reviewed for each piece of equipment. As will be discussed, the selection of the biological process impacts many of the other systems discussed, requiring a cost comparison at the full treatment plant level for the two options. This is discussed further, beginning on page 16. Future specifications will further specify acceptable vendors for each major piece of equipment.

A. Headworks Screening

The preliminary design includes screening at the headworks of the facility. Center flow screens were used as the basis for design. Center flow screens are a proven design and provide a high screening efficiency, particularly when combined with the perforated plate media, which will remove more inert solids from the influent than a bar rack with the same spacing. Additionally, the center flow screens are installed in a vertical position rather than an angle, and therefore do not require as much channel length and have a smaller footprint. They are easy to maintain, as there are no submerged bearings below the water line.

B. Biological Unit Process Alternatives

A previous evaluation[4] of biological treatment alternatives based on qualitative factors concluded that membrane bioreactors were favored over four other alternatives. The second and third ranked alternatives, Conventional Activated Sludge (CAS) and Sequencing Batch Reactors (SBRs), were ranked very close to one another. Of these two, AECOM's experience on smaller treatment facilities is that SBRs are far more cost effective than CAS on both a capital and life cycle cost basis. For the purposes of doing a more quantitative economic comparison of options, SBRs were chosen as a point of comparison to the MBR technology.

1) Membrane Bioreactors (MBRs)

The membrane bioreactor (MBR) process consists of a suspended growth biological reactor integrated with an ultra-filtration membrane system that has a 0.1-micron or less effective pore size. The membranes, supplied as cartridges, are submerged in an aeration tank in direct contact with the mixed liquor. Using a vacuum ("permeate") pump, treated water is drawn through the membranes and discharged. Air is introduced at the bottom of the membrane module producing turbulence, which scours the external surface of the membranes transferring rejected solids away from the membrane surface. This airflow also provides a portion of the oxygen needed for respiration. Concentrated sludge is pumped from the bottom of the tank and a portion of the mixed liquor is recycled to the head of the aeration zone.

Figure 1: Membrane Bioreactor Example - Fibracast FibrePlate (Fibracast)

Periodically the membranes require cleaning which is typically an automated process as prescribed with the membrane equipment manufacturer which occurs within the tank. Cleaning consists of adding a solution of sodium hypochlorite to the MBR tanks using chemical feed pumps and a citric acid wash. In addition, the membranes must be removed from the bioreactor tank for inspection every one to two years.

In general, the benefits to the MBR treatment process include:

- Ability to meet very stringent effluent limits needed for water reuse;
- Smaller footprint than other alternatives;
- Ability to combine secondary clarification and tertiary filtration in a single unit operation;
- Ability to handle varying flows and project phasing requirements; and
- Relatively simple to operate due to automated controls.

[4] "Town of Orleans, MA, Water Quality and Wastewater Planning, Task Number 1 – Facilities Engineering, Deliverable 1.c.10, March 2016"

In general, drawbacks to the MBR treatment process include:

- High life cycle cost due to higher electrical demands/consumption primarily as a result of the aeration requirements;
- Membrane cleaning requires some units to be off-line for treatment;
- Sophisticated timing units and pressure monitoring required for scouring (cleaning);
- Process control modifications are necessary to adapt system to loading variations; and
- Increased solids removal resulting in increased sludge disposal costs.

2) Sequencing Batch Reactors (SBR)

SBRs are often used for medium to smaller facilities. On Cape Cod, Provincetown and Falmouth would be examples of where SBRs are employed. SBRs combine the function of the bioreactor and settling tank into one vessel. The SBR runs in a sequential cycle broken up into different segments for filling, reacting, settling and decanting. Although they do not require a separate settling tank, they typically require flow equalization, which reduces the cost/space savings that would otherwise be realized.

Figure 2: Sequencing Batch Reactors (Aqua-Aerobic Systems, Inc.)

Processes such as nitrification (the oxidation of ammonia-nitrogen to nitrate, NO_3-N) and denitrification (the removal of nitrate by denitrifying bacteria) can be accomplished along with biochemical oxygen demand (BOD) reduction and organic solids stabilization in a single reactor vessel. Most denitrification processes require a supplemental organic carbon source, which is usually a simple carbohydrate such as methanol. By introducing a portion of the incoming waste before the denitrification segment of the SBR cycle, or alternating aerobic anoxic periods during part of the cycle, it is possible to achieve biochemical oxygen demand reduction and nitrogen removal in a single reactor without methanol addition.

The SBR process has been successfully used in industrial and municipal applications for many years. There are five operational steps in the SBR process: (1) fill; (2) react (aeration); (3) settle (clarification); (4) draw (decant); and (5) idle (sludge wasting). The SBR treatment system would consist of multiple tanks with inlets for raw wastewater; air diffusers with associated compressors and piping; a sludge draw off mechanism at the bottom to waste sludge; a decant mechanism to remove the clarified supernatant after settling; and a control mechanism to time and sequence the process. A minimum of two separate tanks are provided for continuous flow-through applications such that one tank receives the wastewater flow filling the tank while the other tank processes the wastewater.

In general, benefits of the SBR treatment process include:

- No separate secondary clarifiers required, reducing footprint size and complexity;
- Automated process controls: timing of units, level sensors and instrumentation;

- Nitrification and denitrification can be achieved without the use of an external carbon source;
- Equipment is readily available through a number of different vendors which promotes competitive pricing;
- Can be built above-ground with exposed tank walls or can be constructed at grade level depending on the terrain of the site and hydraulic considerations; and
- Commonly applied treatment process with a long track record.

Figure 3: Sequencing Batch Reactors at Different Stages (Aqua-Aerobic Systems, Inc.)

In general, drawbacks of the SBR treatment process include:

- Higher level of operating requirements than other technologies due to increased complexity;
- Process control modifications are necessary to adapt the system to flow and load variations; and
- Due to the decant cycle, where an entire batch of wastewater is discharged at once, a post-equalization is typically required, otherwise, the downstream filtration and disinfection systems must be enlarged compared with flow-through type systems.

3) Technical Evaluation of Biological Unit Processes

The biological process selected impacts several other design aspects of the WWTF, including:

- MBR requires finer screening at 2 mm, whereas SBR only requires 6 mm. Additionally, the screening is more critical for MBR operation, such that increased redundancy is required compared to the SBR option.
- The equalization tank pumps must be larger to accommodate increased Total Delivery Head (TDH) when pumping to an SBR compared to an MBR.
- SBR requires a process building, post filtration cloth disk filters, and pumps. The MBR requires a staging/laydown area for access to the membrane tank as well as a small enclosed building to house the chemical feed equipment and pumps.
- SBR option includes a post-equalization tank whereas MBR does not require this. However, the MBR option includes an effluent pump station.

Because the selection of the biological process impacts other units in the treatment train, a full capital cost analysis for complete treatment plants, incorporating each option, needed to be completed. This analysis and resultant recommendation are presented later, beginning on page 16. A further discussion of components common to either option continues as follows.

C. Sludge Thickening Alternatives

The sludge handling system is intended to thicken combined WAS and septage from approximately 0.5 percent solids to 4 to 6 percent solids for off-site disposal. Further dewatering was not selected, as the seasonal variation in both wastewater flow and septage receiving may make it difficult to consistently achieve degree of dewatering that would be required for disposal. The system was designed to operate 6 hours/day for 5 days/week, based on the design basis in Table 6.

Table 6: Sludge Thickening Design Basis

Item, 7-d/week basis	Annual Average	Max Month	Max Week
Plant Flow	0.186	0.261	0.454
WAS Production, gal/d	6,309	8,853	15,397
WAS Production, lbs/d	263	369	642
Septage Receiving, gal/d	16,000	16,000	16,000
Septage Receiving, lbs/d	480	480	480
Blend Production, gal/d	22,309	24,853	31,397
Blend Production, lbs/d	743	850	1122
Blend TSS, %	0.40	0.41	0.43
Assumed Processing Schedule, d/wk	5	5	6
Assumed Processing Schedule, h/d	6	6	6
Hydraulic Throughput Required, gpm	87	97	102
Solids Loading, lbs/m	2.9	3.3	3.6

Several unit processes were evaluated to determine the most cost-effective and efficient method for thickening combined biological sludge and septage at the facility. The technologies evaluated include Disk Thickener, Screw Press, Rotary Drum Thickener (RDT), and Gravity Belt Thickener.

1) Disk Thickener

The disk thickener consists of a stainless steel flocculation tank and tilted cylinder with a rotating stainless steel filter cloth. Flocculated sludge pools at the low point of the disk and static plows on top of the filter open up furrows so water can pass through. A scraper at the outlet pushes thickened sludge from the disk. The filter cloth is cleaned by a spray bar from the underside. The typical performance of these units is to produce 4 to 6 percent solids and 95 percent separation efficiency.

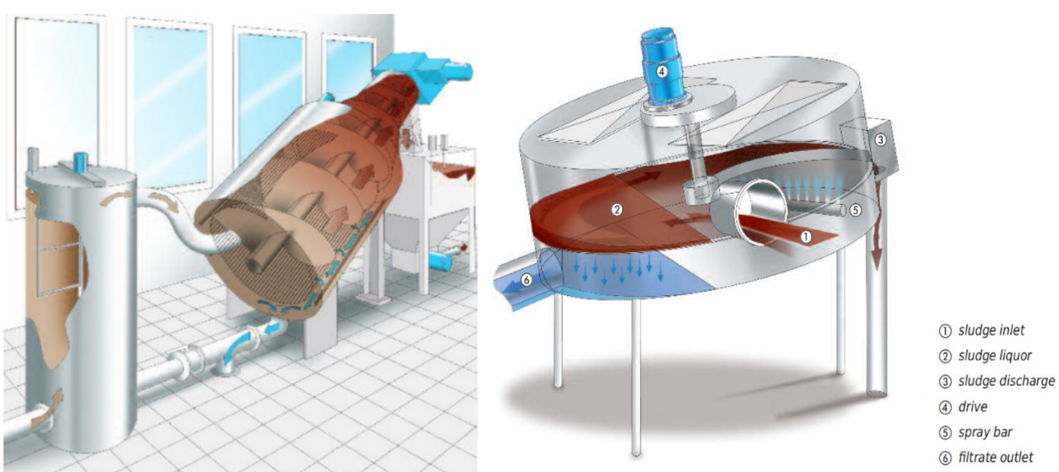

Figure 4: Example of Disk Thickener (Huber Technology, Inc.)

2) Screw Thickener

The screw thickener feeds conditioned sludge into an inclined cylinder that includes a wedge wire basket. A shafted screw slowly rotates and allows the sludge to be conveyed toward the top as liquid flows through the basket and toward a drain at the bottom. These systems typically include spray bars with an automatic wash system. The typical performance of these units is 4 to 6 percent solids with greater than 95 percent capture.

Figure 5: Example of Screw Thickener (Huber Technology, Inc.)

3) Rotary Drum Thickener (RDT)

Rotary Drum Thickeners (RDT) consist of a horizontal rotating basket with several zones of a variety of woven mesh sizes. Conditioned sludge is fed into the rotating screened drums, allowing the water to separate from the solids. Finer mesh is typically used at the feed end, where sludge is thinner, and progresses to larger openings for liquid removal. RDTs are enclosed units and consist of compact designs. Like the screw and disk thickeners, there is an automated wash down process requiring little operator intervention.

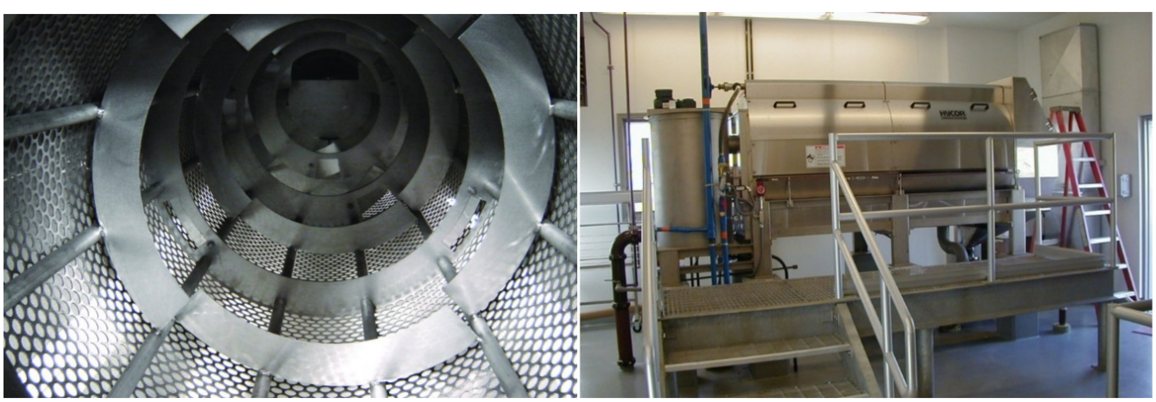

Figure 6: Example of Rotary Drum Thickener (Parkson Corporation)

4) Gravity Belt Thickener (GBT)

Gravity Belt Thickeners (GBT) feed sludge (typically conditioned with polymer) onto a moving belt, which allows the water to drain through the belt as the concentrating sludge moves along. The belts are not enclosed, which can cause odor, corrosion issues and housekeeping issues. They have an adequate service life, however, they require more manual maintenance for cleaning. Typically large volumes of water are required to hose down equipment after each cycle, which can also cause slip hazards for operators. While this technology is time proven, and what was in use at the Tri-Town facility, most new installations are opting for the smaller, more enclosed features of the previous options.

Comparison - The compact footprint, containment of odors, degree of automation make each of the first three options preferred over GBTs. Compared to the screw thickener, disk thickeners or RDTs were determined to be the preferred options, based on cost considerations. The design basis assumes the use of a disk thickener but this can be further evaluated as the design progresses.

D. Odor Control Technologies

Odor control is an important consideration to any treatment facility. Biofilters, chemical scrubbers and activated carbon are all commonly used odor control technologies. Chemical wet scrubbers are commonly applied at larger WWTFs that already have a need for large chemical storage facilities. For smaller facilities, avoiding the hazards of chemical receiving and handling often eliminates wet scrubbers from further consideration. For that reason, activated carbon and biofilters were the two technologies that were evaluated for the Orleans WWTF. The preliminary design includes odor control for the septage receiving garage, headworks building, sludge storage tanks, and equalization tank. The system was designed based on air changes per hour from literature value and assuming that the tanks (WAS, TWAS, and Equalization) were half-full. This design accommodates the first phase, which uses one WAS and one Equalization tank.

Table 7: Odor Control Design Basis

Area	Volume Vapor Space (ft^3)	Air Changes Per Hour	Volume Air (ft^3/min)
Septage Receiving Garage	15,000	18	4,500
Headworks Building	1,040	25	430
Sludge Storage	6,270	18	1,880
Raw Sewage/Septage Receiving (EQ)	10,710	30	5,360
Total			12,170

1) Activated Carbon

An activated carbon is a proven odor control technology that works by adsorbing chemical contaminants from a polluted air stream onto high surface area carbon granules. These small-footprint systems have few controls and are easy to operate. Though the system has a low initial capital cost, carbon media replacement can be costly and the anticipated frequency of change-outs must be considered.

2) Biofilter

Biofilters have become an increasingly applied proven odor control technology that operates based on adsorption and bacterial decomposition of odorous compounds. Moisture levels on the media and biofilm are maintained with either potable water or treated effluent. The system has a larger foot-print and the media is anticipated to treat odors for a minimum of ten years before media replacement may be necessary.

Comparison - Because of significant differences in both capital and operating cost between the two options, a preliminary Life Cycle Cost Analysis ("LCCA") was completed to compare the two odor control technologies. The carbon system replacement costs were based on carbon-media replacement every 550 days for an approximate cost of $42,000 each change-out. Biofilter media replacement costs were estimated at $90,000 with replacement required at year 10. The LCCA showed the carbon 20-year LCC is approximately $858,000 and the biofilter 20-year LCC is approximately $454,000. The carbon system has a 20-year LCC cost approximately 47 percent higher than the biofilter cost. Although the cost of the carbon system is much higher, it is a much smaller footprint than the biofilter. Based on the life cycle costs, the more sustainable nature of biofilters, and the availability of land at the site, biofilters were selected as the odor control technology of choice.

E. Post Filtration

A second solids barrier is recommended for the SBR option. While an SBR can typically produce an effluent with solids concentrations well within permit requirements, the sensitivity of some of the disposal options still under consideration (i.e. Wick Wells), make including a second solids barrier in the WWTF design prudent. The final step in the MBR process is membrane filtration, which provides a physical barrier to solids discharges, making post-filtration unnecessary for MBRs. Three common technologies for post-filtration include sand filters, cloth disks, and a continuous backwash filters. Cloth disk filters are typically the technology of choice to follow SBRs. They are compact, have a low hydraulic profile, are tolerant of solids upsets, and are energy efficient. The Provincetown WWTF has cloth disk filters following their SBRs.

F. Disinfection

The two most common disinfection systems are sodium hypochlorite (NaOCl) and ultraviolet (UV). Disinfection with NaOCl can tolerate more variable effluent quality but requires storage and handling of NaOCl, which is extremely corrosive. UV disinfection is a safe alternative that uses UV light to penetrate the cell wall of the microorganism, rendering it inactive. It does not require dechlorination or have associated disinfectant by-products. The operation does not have the safety and logistical concerns from chemical delivery as the NaOCl disinfection system. The UV system requires a relatively small, compact footprint but requires consistently clean effluent to achieve disinfection standards. Since the proposed design includes post-filtration, good effluent quality is guaranteed and UV can be selected. UV can be configured in open channel or in closed conduits. This preliminary design assumed the UV system would be located in closed conduits due to the hydraulic pumping requirements from the plant to the effluent disposal location. Additionally, the closed conduit can be placed out of the elements in the basement of the Administration/Laboratory building.

G. Infrastructure, Tankage, and Miscellaneous Systems

1) Administration/Laboratory Building

The Administration and Laboratory building is designed to be a space for offices, a small laboratory, and miscellaneous equipment. The first floor will consists of offices, a small laboratory, messing facilities and maintenance space. Adjacent to the office space on the first bay will be a truck bay which will house septage offloading with preliminary screening. This area will also house the sludge thickening equipment. A basement under both the offices and truck bay will house the blowers providing air to equalization basins, WAS storage tank, and TWAS storage tank, as well as the UV system, plant water, sludge thickener feed pump, and miscellaneous process equipment. The building will be designed with an aesthetically appealing exterior as will be further described in the Architectural Section of this report.

2) Septage Receiving

The design assumes that the WWTF can accept 16,000 gpd septage (on average). This capacity is expected to accommodate the non-sewered areas of Orleans, as well as allows for some additional capacity to accept septage from surrounding Towns.

The Sludge Acceptance Plant features a septage receiving system with screens and raking mechanisms, as well as wash press system and grit removal. The septage will then be pumped into the Waste Sludge Storage tank, where it will then be mixed with waste sludge from the biological process and subsequently thickened for off-site disposal. Filtrate from the sludge thickening process will flow to the Equalization Tank where it is mixed with screened sewage and sent to the biological process for treatment. The septage is routed directly to sludge storage rather than to equalization in order to reduce the solids load to the biological process.

3) Headworks and Equalization

The proposed headworks system consists of preliminary fine screen(s) followed by covered flow equalization tanks. The headworks structure will be mounted on-top of the equalization tank and will be enclosed in a small building for weather protection and odor control. Raw wastewater will enter the influent channel in the center from underneath in order to adequately distribute the flow. There will be three channels with diamond plate covers. For the SBR option, the initial phase for the headworks will consist of one 6 mm screen, one manual bar rack, and one future 6 mm screen channel to be installed in the future to accommodate Phase 2 flows. For the MBR option, the initial headworks system will consist of two 2 mm screen channels and one future 2 mm screen channel to be installed in Phase 2. A manual bar rack is not an option for the MBR because its performance requires finer screening and by-passing the screen could result in damage to the membranes. Both headworks systems will collect screenings in a barrel and have a grated platform to provide access to the screens. Because the headworks system is upstream of any flow equalization, the screens are designed for peak hourly flow, which is 931,500 gpd for Phase 1. The headworks layout for both options is shown in **Error! Reference source not found.** and **Error! Reference source not found.**.

The preliminary design includes two equalization tanks, each sized at approximately 150,000 gal. They are designed to be made common by the opening of a gate valve separating the two tanks. One tank is sufficient for Phase 1 flows, while both would be required for Phase 2. Because the tanks are below grade and have common wall construction with the some of the other below grade tankage, it is prudent from a construction cost standpoint to build both initially. The volume required was based on the desire to mitigate peak hourly flows within a peak day scenario such that the flow to downstream processes would be limited to the anticipated max day flow for Phase 1 of 521,600 gpd, plus a 15 percent allowance for modest flow control fluctuations, recycles, etc. The equalization tank will receive filtrate flow from the sludge thickening system, and in the case of the SBR option, backwash from filter cleaning cycles. The equalization tanks will be covered with odor control.

Three 50 percent pumps (2 duty, 1 standby) will pump the wastewater from the equalization tank to the biological treatment process. The tank will also include two additional guard rail assemblies and space for two future pumps if needed for Phase 2 implementation. The equalization tank pumps are sized slightly larger for the SBR option, due to the higher hydraulic grade line associated with the SBRs.

4) Post Equalization/Effluent Pump Station

SBRs discharge flow on a non-continuous basis. In the design proposed for the Orleans WWTF, at peak flow each SBR will discharge flow for only one hour for every 5 hour cycle (i.e. batch). To normalize flow through the disinfection process and ultimately to the effluent disposal beds, a post-equalization tank is provided for the SBR option. This tank would be sized at 50,000 gallon and would be located partially below grade in order to receive flow by gravity from the cloth disk filters.

A post-equalization tank is not required for the MBR option, as MBRs discharge flow essentially on a continuous basis, however a partially below grade effluent pump station would be needed to receive flow from the MBRs and pump it through the disinfection system out to the effluent disposal beds. The effluent pump station wet-well would be 20 feet by 8 feet, with a depth of 10 feet. It would be sized to accommodate five pumps, two duty and one standby for Phase 1 flows, with space to accommodate an additional two duty pumps for Phase 2.

5) Effluent Pumping

The effluent pumps were estimated to require 135 feet of TDH based on an effluent disposal location 6,500 linear feet away from the site and 25 feet elevation increase. The ultimate effluent disposal location has not yet been determined and therefore, this design may need to be revised if it varies significantly in distance and/or elevation. The proposed design includes three pumps, each sized to handle 50 percent of the maximum flow (210 gpm), along with guard rail assemblies for two future pumps. In the SBR option, the pumps will be located in the post-equalization tank that follows the SBR. In the MBR option, the pumps will be located in the effluent pump station.

6) Sludge Storage

The septage received at the WWTF will be routed directly into a tank with the Waste Activated Sludge ("WAS") from the biological process prior to thickening. WAS will be transferred to the thickener located in the truck bay via a thickener feed pump located in the basement of the Admin/Lab building. After thickening, thickened WAS ("TWAS") will flow by gravity from the thickener into a TWAS tank.

Based on AECOM's experience at the Provincetown facility, transportation of thickened sludge from the lower/outer Cape can be a challenge, particularly during the summer when traffic is a concern. It is important to provide sufficient storage volume for both WAS and TWAS to accommodate maintenance outages of the thickening equipment, staff work scheduled (i.e. long holiday weekends), etc. The recommended WAS and TWAS volumes and what they provide for storage capacity under both Phase 1 and Phase 2 conditions is as shown below. Note that the WAS storage volume is smaller for the MBR option due to the fact that the sludge wasted from a MBR process is anticipated to be twice as concentrated as it would be for the SBR option.

As can be seen from Table 8, the planned for WAS/Septage storage for either option provides just approximately 3 days storage under max week conditions for Phase 1, and just over 2 days for projected Phase 2. In an emergency, additional time could be gained by temporarily halting septage receiving, which makes up a large portion of the storage tank requirements. Similarly, thickening for TWAS was based on projected max week conditions for both the Phase 1 and Phase 2.

Table 9 shows that the 25,000 gallons planned for TWAS storage provides just over 6 days storage under max week conditions for Phase 1, and just over 4 days for projected Phase 2. This provides sufficient storage volume to accommodate any short-term disruptions in transportation due to weather, traffic, or contractual issues should they arise.

7) Aeration Systems

Coarse bubble diffusers will be provided for mixing the equalization tank, WAS tank, and TWAS tank. Approximately 380 scfm is required per equalization tank, 475 scfm per WAS tank, and 630 scfm in TWAS tank. Therefore, four blowers sized for 250 scfm can accommodate the equalization tank and WAS tank for Phase 1. Two additional blowers sized for 650 scfm can accommodate the TWAS tank and serve as a spare. All of these blowers will have a 7.1 psig discharge pressure and will be configured with noise enclosures.

Additionally, the SBR or MBR system would be provided with necessary diffusers and blowers required to operate that system.

Table 8: WAS Storage Summary

Description	SBR Option		MBR Option	
	Phase 1	Phase 2	Phase 1	Phase 2
Max Week WAS Production, lbs/d	642	1,118	642	1,118
Assumed WAS TSS, %	0.50	0.50	1.0	1.0
Max Week WAS Production, gal/d	15,397	26,812	7,699	13,406
Septage Delivery, gal/d	16,000	16,000	16,000	16,000
Design Volume, gals	120,000		85,000	
Actual Storage Capacity, d	3.1	2.2	2.9	2.3

Notes: 1. Storage capacity includes a 20 percent factor of safety.
2. Phase 2 production and septage delivery values listed include both Phase 1 and Phase 2 flows and represents the total design rather than the incremental additional production associated with Phase 2.

Table 9: TWAS Storage Summary

Description	Phase 1	Phase 2
Assumed Septage TSS, mg/l	3,600	3,600
Septage TSS, lbs/d	480	480
Assumed Thickener Capture, %	95	95
Assumed TWAS TSS, %	4.0	4.0
TWAS, lbs/d	1,066	1,519
TWAS, gal/d	3,196	4,552
Design Volume, gals	25,000	25,000
Actual Storage Capacity, d	6.3	4.4
Filtrate Flow, gal/d	28,201	38,260

Notes:
1. Storage capacity includes a 20 percent factor of safety.
2. Phase 2 production and septage delivery values listed include both Phase 1 and Phase 2 flows and represents the total design rather than the incremental additional production associated with Phase 2.

H. Capital and Life Cycle Cost Estimates for Evaluation of Preferred Plant Layout.

As previously discussed, the two options selected for comparison for the biological process were SBR and MBR. Because these two options have different requirement for both upstream (e.g. – screening) and downstream (e.g. – post filtration/equalization) systems, a comparison of the two required the layout and cost estimation at the full plant level for each. A comparison of the major plant systems for each is as shown in Table 10.

Table 10: Comparison of Major Plant Systems for SBR and MBR Options for Phase 1

Description	SBR	MBR
Headworks/Screening	1 @ 6 mm center flow screen, 1 @ manual bar rack	2 @ 2 mm center flow screen
Equalization	2 Tanks @ 150,000 gal/ea	2 Tanks @ 150,000 gal/ea
Reactor Tankage	2 Tanks @ 229,000 gal/ea	2 Tanks @ 87,500 gal/ea
Post Filtration	2 @ 100% cloth disk filters	2 @ 100% membrane cassettes
Post Equalization/Effluent Pumping	1 Tank @ 55,000 gal	1 Tank @ 12,000 gal
Disinfection	2 UV Units with 16 lamps/ea	2 UV Units with 16 lamps/ea
Septage/WAS Storage	2 Tanks @ 60,000 gal/ea	2 Tanks @ 42,500 gal/ea
Thickened Sludge Storage	1 Tank @ 25,000 gal	1 Tank @ 25,000 gal

Process flow diagrams (PFDs) for the MBR and SBR Options are as shown in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively.

A review of Table 10 shows that there are several differences between the two designs. The MBR has smaller volume requirements for the bioreactors and the WAS storage tanks, and requires a smaller effluent pump wetwell versus the larger post-equalization basin included in the SBR design. The SBR option required a lower degree of screening.

In order to assess the differences in the two designs, a cost estimate needed to be developed that included not only the cost of the process equipment for each option, but the full installed costs including tankage, buildings and ancillary equipment. **Error! Reference source not found.** through **Error! Reference source not found.** show the overall site layout, building elevations, floor plans & sections, and a preliminary hydraulic profile used in the development of construction costs for each option.

Table 11 summarizes the estimated total project cost for each of the two options. The cost estimates were derived from vendor proposals for all major process equipment, a detailed assessment of concrete, building materials, and site work required to build the necessary tanks/structures, and standard allowances for some plant wide items as follows:

- Electrical: 20 percent project cost;
- I&C: 50 percent of electrical;
- Piping: 15 percent of mechanical equipment; and
- 22 percent contractor, GC, overhead, and profit.

More detailed information on the installed costs estimates for both options are found in Appendix A.

Table 11: Summary of Installed Cost for Two Process Options

Description	MBR Option	SBR Option
Total Direct Costs (equipment, construction material, direct labor)	$7,850,000	$7,715,000
Contractor's General Conditions, Overhead and Profit (22% of Direct Cost)	$1,730,000	$1,700,000
Project Contingency (30%)	$2,875,000	$2.825,000
Owner Contingency (5%)	$620,000	$610,000
Subtotal (2nd Qtr CY 2017)	$13,075,000	$12,850,000
Escalation to Construction Mid-point (assumed December 2019)	$1,200,000	$1,180,000
Total Project Cost	$14,275,000	$14,030,000

As one can see, the capital costs for the two options are extremely close, within the margin of error of the estimate; however it is appropriate to also consider the operating costs over longer period of time, typically 20 years. A combined evaluation of capital and operating costs over a 20 year period is commonly referred to as life cycle cost analysis ("LCCA"). In that a LCCA in this case is being used to compare two options, only operating costs that are different between the two were included in the analysis. Operating costs that would not be expected to be appreciably different between the two (e.g. facility heating, lighting, etc.) were not included. A comparison of operating costs that would be expected to be different between the two options is shown in Table 12.

Table 12: Comparison of O&M Cost Differences for SBR and MBR Options for Phase 1

Description	MBR Option	SBR Option
Annual Costs		
Cleaning Chemicals	$700	$0
Bioreactor Power Costs	$22,275	$17,300
EQ to Bioreactor Pumping Costs	$5,250	$10,500
Non-annual Costs		
Membrane Replacement (every 10 years)	$120,000	$0

A 20-year LCCA analysis is presented in **Error! Reference source not found.**, at the end of the TM. This analysis was based on the following assumptions:

- General Inflation Rate: 3.0 percent;
- Electricity Inflation Rate: 3.3 percent; and
- Discount Rate: 1.5 percent.

A different inflation rate for electricity was used than for general inflation based on the fact that electricity costs are driven by a number of factors above those influencing general inflation (i.e. – transmission congestion, etc.). Energy inflation was derived using projections produced by the U.S. Department of Energy's Energy Information Administration, specific to commercial users in the Northeast United States.

As shown in **Error! Reference source not found.**, the 20-year life cycle cost for the MBR Option is $15.1 million while for the SBR Option, it is $14.7 million. As was the case with the construction costs, the life cycle costs are close enough to be considered within the estimate's margin of error.

AECOM's original recommendation in the 2016 concept evaluation[5] report based on qualitative rankings listed MBRs as more favorable than SBRs in total. The assessment of some of the factors that led to this recommendation has shifted somewhat in the ensuing months, with the benefit of further defining the compete installation of both options, and experience gained at other sites. It should be noted that the design development for the SBR option included the addition of some features aimed at leveling some of the non-economic differences between the two technologies. Areas where MBR ranked markedly higher than SBR in the previous evaluation and current thoughts on these selection criteria are as follows.

1. Operational Complexity: AECOM originally rated MBRs higher (more favorable) for operational complexity than SBRs. This was based on the fact that the MBR provides a barrier preventing solids carry-over to the disposal beds, making control of good solids settling characteristics within the biomass less important than with SBR systems. In the development of the design however, AECOM has included post filtration for the SBR option, which mitigates the SBRs potential for solids upsets. AECOM would additionally note that the MBR system requires the use of chemicals for periodic cleaning of the membranes which are not required of the SBR system. The addition of post-filtration to the current SBR design and the lack of a requirement for periodic chemical cleaning mitigate the advantage that MBRs previously displayed in the 2016 evaluation.
2. Expansion Capability: AECOM has laid out the design of both options to readily accommodate the potential doubling of flow from possible future collection system phases for the Downtown and Meeting House Pond areas.
3. Ability to Achieve Potential Stricter Limits (P, lower N): A review of operating data from the nearby SBR system at Provincetown indicates that their SBR system is readily achieving effluent TN concentrations well below the anticipated limit of 10 mg/l. Discussions with MassDEP do not indicate any potential for a P limit for the foreseeable future. Should one arise, both technologies, as currently laid out, would require additional systems for P removal.
4. Compatibility with Wick Well for Effluent Disposal: Similar to the discussion on Operational Complexity, the higher rating for MBR in this category was due to the fact that the MBR provides a solids barrier preventing solids carry-over to the disposal beds. The addition of post-filtration to the SBR design has level both technologies in this category.
5. Footprint Required: As can be seen by comparing the site plans for both options, the bioreactors for the MBR option are indeed smaller, but not by as much of a margin as anticipated. When all ancillaries structures, tanks, and buildings are added, the difference in overall footprint is negligible, and of little consequence given the land available at the Overland Way site.

In summary, features have been included in the current layout of the SBR design to mitigate some of the perceived disadvantages relative to MBRs noted in the previous evaluation. Even with these additional features, the SBR layout remains competitive from a cost standpoint.

[5] "Town of Orleans, MA, Water Quality and Wastewater Planning, Task Number 1 – Facilities Engineering, Deliverable 1.c.10, March 2016"

One evaluation criterion that was not included in the previous evaluation was the commonality of the technology in the region. At all the municipal treatment plants located on Cape Cod, there are two SBR systems (Provincetown and Falmouth), but no MBR systems. Additionally, the smaller system located at the Massachusetts Maritime Academy in Bourne is an SBR system. This means that the ability to find operations staff in the region with hands-on experience with the selected technology will be easier with SBR than MBR.

AECOM believes both options remain technically viable, and by all indications, the cost differences are negligible. The fact that SBRs are more common in the region provides some benefits however in terms of locally available staff and technical support which are familiar with the technology, and believes this acts as something of a “tie-breaker”. As a result, AECOM’s recommendation for future design development is a plant based on the SBR technology.

6. Description of Proposed WWTF

A. General

The Orleans WWTF will be designed to remove conventional pollutants (BOD and TSS) and to significantly reduce the amount of total nitrogen levels in the effluent prior to groundwater discharge. The following is a summary of the major proposed treatment components:

- Administration/Laboratory Building with Septage Receiving Truck Bay
- Covered Headworks with Influent Micro Screening with manual bar rack by-pass
- Flow Equalization and Flow Splitting
- Sequencing Batch Reactor Tanks
- Process Building housing post-SBR filters and SBR blowers
- Post Equalization Tank (Effluent Pump Station);
- Ultraviolet disinfection units providing final treatment prior to disposal via groundwater discharge;
- Effluent Sampling and Flow Measurement;
- WWTF effluent piping to groundwater discharge site(s);
- Two sludge holding tanks;
- Sludge thickener, thickened sludge holding tank, and sludge load-out station; and
- Biofilter for odor control to treat odorous air exhausted from the headworks, equalization tank, and sludge holding tanks.

B. Process

The major process equipment for the recommended WWTF design is as shown in Table 13.

Table 13: Recommended WWTF Major Equipment

Major Process Equipment	Description (Duty/Rating/Capacity)	Quantity	Design Basis
Preliminary Screening – 6 mm	0.60 MGD	1 Duty; 1 Future; 1 Manual Bar rack by-pass	Hydro Dyn Engineering Model# CF23-12-73-6-P
Equalization Tank	150,000 gal tanks (35' x 34' x 18')	2	N/A
Equalization Transfer Pump	210 gpm at 40' TDH	2 Duty; 1 Standby; 2 Future	Sulzer/ABS Model XFP 100E-CB1 PE56/4
SBR Reactor Tanks	229,000 gal tanks (35' x 35' x 25')	2	Aqua-Aerobic Systems, Inc. AquaSBR
Disk Filters (post-SBR)	815 gpm	2	Aqua-Aerobic Systems, Inc. AquaDisk
Post-Equalization Tank	55,000 gal (34' x 12' x 18')	1 Duty	N/A
Effluent Discharge Pumps	210 gpm at 135' TDH	2 Duty; 1 Standby; 2 Future	Sulzer/ABS Model XFP 101G-CB1 PE185/2
UV	0.60 MGD; Minimum dose: >29 mJ/cm^2	1 Duty; 1 Standby 16 maps each	WEDECO LBX series
Septage Receiving	700 gpm at 3% D.S.	1 Duty	HUBER Sludge Acceptance Plant Model: RoFAS1
Sludge Thickening	89 gpm at 0.52% sludge concentration	1 Duty	HUBER S-Disc Size 1 Disk Thickener
Odor Control - Biofilter	12,170 cfm 40' x 25' x 6.1'	1 Duty	Biorem Technologies Inc. Modular Biofilter System
Coarse Bubble Diffusers	Equalization Tank: 380 scfm WAS Tank: 475 scfm TWAS Tank: 630 scfm	Equalization Tank: 36 diffusers in 2 grids WAS Tank: 40 diffusers in 2 grids TWAS Tank: 128 diffusers in 2 grids	Aquarius Stainless Coarse Bubble Diffused Aeration
Mixing Blowers	250 scfm at 7.1 psi 650 scfm at 7.1 psi	4 Duty 1 Duty; 1 Standby	Aerzen Rotary Lobe Blower GM 10 S, LU 43.01; Aerzen Rotary Lobe Blower GM 25 S, LU 43.01;

C. Civil/Site Work

Civil and site work for the WWTF will include grading, drainage, and site improvements. In general, fill slopes that are not subject to vehicular traffic will be graded at a 3 to 1 slope. Slopes that are subject to vehicular traffic will be graded at a maximum slope of 8 percent. All disturbed areas will be loamed and seeded, except where driveways or sidewalks are shown. In addition, some shrubs and trees will be provided as needed for landscaping in areas adjacent to the buildings and structures.

Areas that require routine vehicle access will be bituminous concrete roadways, consisting of a 15-inch gravel base course, a 2-1/2-inch bituminous concrete binder course and a 1-1/2-inch bituminous concrete top course. Areas that require routine pedestrian access will have concrete sidewalks. The sidewalk will consist of 4-inches of reinforced concrete on an 8-inch gravel base course and will have granite curbing.

Areas that surround structures or buildings will typically have a stone maintenance strip, which will be 6-inches thick and 3-feet wide. The stone maintenance strip will have a pervious weed barrier installed below the stone layer. The maintenance strip will have pre-molded aluminum edging material.

Painted steel bollards (approximately 4-inches in diameter and 42-inches tall) will be provided as needed to protect equipment or structures that are near roadways. Fencing will be located around the outer perimeter of the site for security.

The clearing and grubbing areas required for this project will be minimized to the extent possible. Landscaping and planting at the sites will be such that they are blended into the existing surrounding conditions to the extent possible.

D. Geotechnical

Existing soils information (borings and monitoring wells) exists from the construction of the Tri-Town Septage Treatment Facility. In addition, additional soil information (test pits, borings and monitoring wells) was obtained during the potential groundwater disposal site investigation/evaluation. Additional borings and monitoring wells will be required at the WWTF site and the groundwater disposal site during the detailed design of these facilities.

E. Architectural

It is anticipated that the WWTF buildings will be framed with wood or metal stud interior walls, 2 inch by 6 inch at 16 inches on center or concrete block depending upon the building usage. Interior surfaces will be finished as shown on Table 14, Preliminary Room Finish Schedule. Fiberglass batt insulation will be used in all ceilings and walls.

The exterior walls of the WWTF buildings will be white cedar shingles. All doors, frames and air louvers will be anodized aluminum with colors selected during the design. All windows will be vinyl clad with insulating glass. Roof will be a prefabricated wood truss with plywood sheathing. Asphalt shingle roofing material will be used.

Table 14: Preliminary Room Finish Schedule

	Location						
Description	**Floor**	**Base**	**North Wall**	**East Wall**	**South Wall**	**West Wall**	**Ceiling**
First Floor							
1. Office	VT	V	G/P	G/P	G/P	G/P	A
2. Entry Area	C/S	V	G/P	G/P	G/P	G/P	A
3. Restroom	CT	V	G/P	G/P	G/P	G/P	G/P
4. Stairway	C	V	G/P	G/P	G/P	G/P	G/P
5. Chemical Area	C/SL	C/SL	G/FP	G/FP	G/FP	G/FP	G/P
6. Electrical Room	C/S	V	G/P	G/P	G/P	G/P	G/P
7. Laboratory	C/VT	V	G/P	G/P	G/P	G/P	G/P
8. Truck Bay	C/S	C	FP	FP	FP	FP	FP
Basement							
1. Equipment Area	C/S	C	C/P or C/SAP	C/P or C/SAP	C/P or C/SAP	C/P or C/SAP	C/P or C/SAP

LEGEND:

A - Acoustical Ceiling
P - Paint
S - Sealer, hardener
V - Vinyl
VT - Vinyl Tile
C – Concrete
G – Gypsum Drywall
FP – Fiberglass Panels
CB - Concrete Block
SAP - Sound Absorption Panels
CT - Ceramic Tile
WP - Waterproofing
SL - Synthetic Liner
GB – Glazed Block

F. Structural

All reinforced concrete structures will be designed in accordance with the latest editions of the American Concrete Institute (ACI) 318, ACI 350 and the Massachusetts Building Code. Structural concrete will be 4,000 pounds per square inch (psi) compressive strength using Type II cement conforming to ASTM C150 and aggregate conforming to ASTM C33. Reinforcing steel will be Grade 60 in accordance with ASTM A615. Tanks will be constructed as integral members of the building foundation structure.

Polyvinyl chloride (PVC) waterstops will be provided at all construction joints in hydraulic structures. Membrane waterproofing will be provided on the walls of all hydraulic structures that are common with the building and where the normal water level extends above the finish grade adjacent to the structure. Waterproofing of slabs will be provided by specifying an adequate slab thickness, or using membrane waterproofing compounds.

The following areas will be covered to control odor emissions: (a) Influent Screening and by-pass channels, (b) Equalization Tank, and (c) Sludge Holding Tanks. Concrete will be used to cover all tanks with portions of the membrane bioreactor basins that will have flat aluminum tread plate covers with recessed drop handles. Aluminum will be ASTM Alloy 6061 or 6063. Aluminum access hatches will be used on the sludge holding tanks.

G. Plumbing

The Wastewater Treatment Facility will have plumbing facilities as required to meet all local, state and national building codes. The plumbing system will be designed based on the latest edition of the following standards and codes:

- National Fire Protection Association (NFPA);
- BOCA Basic National Plumbing Code; and
- Massachusetts State Plumbing Code.

The plumbing requirements in the Wastewater Treatment Facility Building include:

- Drain piping, floor and equipment drains;
- Heating and Ventilation;
- Emergency eyewash/shower fixtures in any chemical storage location; and
- Toilet and Sink.

H. Heating and Ventilation

Heating and ventilation systems for the Wastewater Treatment Facility Building will be designed based on the latest edition of the following standards and codes:

- ASHRAE Handbook and Publications;
- BOCA Code;
- NFPA Life Safety Code; and
- TR-16 - Guides for the Design of Wastewater Treatment Works, (2011 Edition as Revised in 2016) by the New England Interstate Water Pollution Control Commission.

The outside design temperature will be based on the 97.5 percentile dry bulb winter temperature of minus 7 degrees Fahrenheit for heating. The outside summer design temperature at the 2.5 percentile is 85 degrees Fahrenheit dry bulb (70 degrees Fahrenheit wet bulb) for exhaust air ventilation. Inside design spaces will be heated to 70 degrees Fahrenheit if they are routinely occupied. Process work areas will be heated to 55 degrees Fahrenheit. Process tanks will not be heated.

All equipment and pump rooms are dry, and will be ventilated at a rate of 6 air changes per hour as outlined in NFPA 820 standards.

Hot water recirculating heat will be used with three speed electric fans on each unit heater. All HVAC Ductwork will be galvanized steel sheet metal.

I. Electrical

Electrical power for the WWTF will be serviced from the local power company. The facility will be served by a separate electrical service and separate stand-by generator for emergency power. Electrical service will be provided at 480 volt, 3-phase, 4-wire, 60 Hertz via a pad-mounted transformer. Sizing of the transformer shall be coordinated with the Power Company based on submission of electrical load sheets for this project. Three phase power will be required on-site for proposed facilities. It is assumed that 3-phase power will be picked up from the street and brought into the WWTF along the existing access road. Electrical load sheets for the facility will be compiled and submitted to the Power Company for review.

The electric service equipment shall consist of a main incoming service circuit breaker disconnect, automatic transfer switch, switchboard distribution and motor control centers including dry-type transformers and lighting panels for low voltage distribution. The electrical distribution equipment shall be housed, for the most part, within the electrical room of the WWTF. In some circumstances equipment such as lighting panels, dry-type transformers, pull-boxes, and specific control panels may be located throughout the facility as to allow proper electrical connections to specific process equipment.

The WWTF will be provided with stand-by power in the form of an on-site, diesel generator with a capacity of approximately 250 kilowatts (KW). The generator will be located outside of the building in a weatherproof, acoustical enclosure and be shall be sized to operate the entire WWTF based on the designed capacity for this facility and the equipment necessary for permit compliance. The electrical controls will allow for both automatic and manual operation of the generator in order to provide stand-by power at the treatment facility. Upon power failure, the transfer switch will call for the generator to start. As soon as the generator is producing a stable 60 Hz electrical feed, the power shall be transferred. The equipment shall then be sequentially restarted, beginning with life safety functions, then the critical process equipment (such as air supply blowers) and ending with the non-critical process items. The following is a summary of the anticipated facility equipment, which shall be operated by the stand-by generator:

- Preliminary Screening (1 at 0.5 HP each);
- Screen Washing Compactor (1 at 1.5 HP each)
- Mixing Blowers (4 at 15 HP each; 1 at 40 HP);
- Transfer Pumps (2 at 7.5 HP each);
- Aeration Blowers (3 at 20 HP each);
- SBR Disk Filters (1 at 2.5 HP);
- SBR Transfer Pumps (2 at 2.4 HP each);
- Sludge Holding Tank Pumps (1 at 5 HP);
- UV Disinfection System (1 at a total connected load of approximately 13.9 HP);
- Effluent Pumps (2 at 25 HP each);
- Sludge Thickener (1 at 1 HP);
- Biofilter Fan and Recirculation Pump (1 at 35 HP);
- Heating, Ventilation and Lighting; and
- Plant Water Skid (1 at 3 HP)

The electrical conduit for the project shall either be galvanized rigid steel, PVC coated rigid steel, Schedule 40 and Schedule 80 PVC based on the location and installation for the project. Corrosive areas, such as Headworks, Chemical Fed and Storage Areas, and Solids Storage and Processing Areas, will require the use of PVC coated or Schedule 80 PVC conduits. Galvanized rigid steel conduits shall be installed in general use areas. The intended design and installation is to provide for a long-term use capable of withstanding the harsh environments of a wastewater treatment facility.

Underground conduits shall be concrete encased between buildings and structures and for incoming electrical service. Underground conduits shall be Schedule 40 PVC, concrete encased, except galvanized rigid steel shall be used for all signal cables or unless otherwise noted, and galvanized rigid steel conduit shall be provided 10 feet from buildings or structures. Conduits will be brought into structures above grade to prevent the possibility of water leaking into lower areas of the building. Interior conduits shall be installed exposed.

All wires shall be AWG copper throughout the installation. The sizing and type of wiring insulation shall be based on the installation requirements (underground, within building) and the equipment loading requirements sized per the National Electrical Code (NEC).

Indoor lighting in the WWTF areas will be energy efficient LED fixtures. Lighting levels within the specific locations shall meet industry standards, but for the most part shall be between 25 and 30 foot candles. Site lighting shall be provided to allow general access to and from facility structures and shall be installed to allow both manual and automatic operation. General outdoor lighting shall be designed for both efficiency and economic considerations. Fixture type shall be incandescent, high-pressure sodium or metal halide as determined by the final design considerations. Explosion-proof incandescent fixtures will be provided within the Headworks building as required by code. Emergency lighting shall be provided at required locations to allow proper access as required by code.

The design will comply with the National Electrical Code (NEC) and other applicable state and local code requirements. Electrical equipment will be specified to meet the requirements of Underwriters Laboratories, Inc. (UL), National Electrical Manufacturers Association (NEMA) and other recognized industry standards. Electrical equipment design and installation will follow any available energy programs being offered by the Power Company. This will consider all available energy efficient equipment, to provide both short and long-term energy savings.

J. Instrumentation

1) General

The instrumentation and controls for the WWTF shall incorporate the use of Programmable Logic Controllers (PLC) based Supervisory Control and Data Acquisition (SCADA) system control to operate and monitor the process. The intent of the SCADA system is to provide monitoring and alarms so that 24-hour per day staffing is not necessary.

The extent of the SCADA system provided will be limited to the instrumentation and control panels supplied by each OEM (Original Equipment Manufacturer) and will be tied into one main Control Panel. The main Control Panel will provide a central location for all process monitoring and alarm conditions using an Operator Interface Panel. This panel will allow the Operator to view alarm history and manually record such events.

2) PLC System

A PLC is an industrial, real-time, solid-state control system that runs ladder logic programs. Its capacity and functionality can be expanded or modified as required. It is suitable for temperature, humidity, vibration, and voltage variations found in the WWTF. It is designed to run 24 hours a day, seven days a week. The benefits of using PLCs are high reliability, flexible control, easily modified programs, expandability, easy troubleshooting, small space requirements, low cost, and modular design. A PLC based control system will be provided by the MBR manufacturer for operation and control of their complete process.

3) Alarms

Both digital and analogue alarm conditions will be managed by the plant SCADA system. The alarm management system shall categorize alarms based on degree of criticality to safety and/or plant operations. The system shall include a call-out feature to notify on-call staff of the nature and location of the alarm conditions. An alarm/event log will be included as part of the system.

4) Instruments

Table 15 presents a preliminary list of instruments for process monitoring and control at the WWTF.

Table 15: Preliminary List of Instruments

Signal Source	Quantity	Primary Element
Influent/Headworks		
Flow	1	Magnetic Flow Meter
Channel Level	1	Ultrasonic Level Element
Bio-Reactors		
Level	2	Ultrasonic Level Element
Temp	2	Temperature Element
TSS	2	Photo optic Sensor
DO	2	LDO Probe
NH3-N	2	ISE Element
NO3-N	2	ISE Element
pH	2	ISE Element
ORP	2	Probe
WAS Flow	2	Magnetic Flow Meter
Post Filtration		
Basin Level	2	Ultrasonic Level Element
Effluent Level	2	Ultrasonic Level Element
Post EQ Tank		
Level	1	Ultrasonic Level Element
Effluent Flow	1	Magnetic Flow Meter
Turbidity	1	Transmissivity Sensor
Disinfection		
UV Intensity	2	Photo sensor

Signal Source	Quantity	Primary Element
Biosolids Processing		
WAS Tank Level	2	Ultrasonic Level Element
TWAS Tank Level	1	Ultrasonic Level Element
Septage Receiving Flow	1	Magnetic Flow Meter

7. Process Equipment

A. General

The Orleans WWTF will require various types of piping, valves, and process equipment, as presented in the following paragraphs.

B. Piping

Various pipe materials will be used for the construction of the Orleans WWTF. Valves

Various valves will be used for the construction of the Orleans WWTF and are shown in **Error! Reference source not found.** on the preliminary Valve Schedule. The valve schedule may be expanded to include additional situations as the project proceeds through final design.

Table 16: Valve Schedule

Process Description	Type of Valve
Raw Wastewater Exterior	Sluice Gate, Slide Gate or Stop Plate
Raw Wastewater Interior	Plug Valve
Effluent Interior	Solid Wedge or Resilient Seat Gate Valve
Effluent Exterior	Sluice Gate, Slide Gate or Stop Plate
Sludge	Plug Valve
Chemicals	PVC Ball Valve
Air	Butterfly Valve
SBR Influent	Motor-Operated Plug Valve
SBR Air	Motor-Operated Butterfly Valve
SBR Wasting	Motor-Operated Butterfly Valve
SBR Decant	Motor-Operated Butterfly Valve

C. Mechanical Equipment

The major mechanical/process equipment was listed in Table 13. The equipment list describes general sizing criteria and design basis information. The equipment selection may be expanded or updated as the project progresses through final design.

Table 17 shows the preliminary Piping Legend and contains the pipe materials proposed for the design. The pipe materials may be expanded and/or refined as the project proceeds through final design.

D. Valves

Various valves will be used for the construction of the Orleans WWTF and are shown in **Error! Reference source not found.** on the preliminary Valve Schedule. The valve schedule may be expanded to include additional situations as the project proceeds through final design.

Table 16: Valve Schedule

Process Description	Type of Valve
Raw Wastewater Exterior	Sluice Gate, Slide Gate or Stop Plate
Raw Wastewater Interior	Plug Valve
Effluent Interior	Solid Wedge or Resilient Seat Gate Valve
Effluent Exterior	Sluice Gate, Slide Gate or Stop Plate
Sludge	Plug Valve
Chemicals	PVC Ball Valve
Air	Butterfly Valve
SBR Influent	Motor-Operated Plug Valve
SBR Air	Motor-Operated Butterfly Valve
SBR Wasting	Motor-Operated Butterfly Valve
SBR Decant	Motor-Operated Butterfly Valve

E. Mechanical Equipment

The major mechanical/process equipment was listed in Table 13. The equipment list describes general sizing criteria and design basis information. The equipment selection may be expanded or updated as the project progresses through final design.

Table 17: Piping Legend

Abbreviation	Description	Type of Flow	Pipe Material
AS	Air Supply	Pressure	Stainless Steel
DEC	Sludge Decant	Gravity	Ductile Iron
DR	Drain	Gravity	Ductile Iron
EFF	Effluent	Gravity	Ductile Iron
EFFL	Effluent to Groundwater Disposal	Gravity/Pressure	PVC
FDr	Floor Drain	Gravity	Cast or Ductile Iron
Fuel	Fuel	Pressure	Copper or Steel
INF	Influent	Pressure	Ductile Iron
ODOR	Odor Control Ductwork	Pressure	PVC (Buried) and PVC or FRP (Interior/Exposed Exterior)
OVER	Overflow	Gravity	Ductile Iron
PDr	Process Drain	Gravity	Ductile Iron
Poly	Polymer Solution Feed	Pressure	
PWD	Plant Water Discharge	Pressure	DI > 3 inch, Copper < 3 inch
PWS	Plant Water Suction	Pressure	Ductile Iron
Recird	Recirculation Discharge		
Recirs	Recirculation Suction		
SBRE	Sequencing Batch Reactor Effluent	Gravity	Ductile Iron
SBRI	Sequencing Batch Reactor Influent	Gravity	Ductile Iron
SD	Sludge Discharge	Pressure	Ductile Iron
SDr	Storm Drain	Gravity	Ductile Iron
SL	Sample Line	Pressure	Polyethylene
SPD	Sump Pump Discharge	Pressure	PVC
SS	Sludge Suction	Pressure	Ductile Iron
STD	Sludge Transfer Discharge	Pressure	Ductile Iron
STDr	Sludge Transfer Drain	Gravity	Ductile Iron
STS	Sludge Transfer Suction	Pressure	Ductile Iron
TW/DW	Town Water/Domestic Water	Pressure	DI > 3 inch, Copper < 3 inch
UV	Ultra-Violet	Pressure	Ductile Iron
VENT	Vent	Gravity	PVC
WASS	Waste Activated Sludge Suction	Pressure	Ductile Iron
WASD	Waste Activated Sludge Discharge	Pressure	Ductile Iron

8. Preliminary Plans, Specifications, and Required Permits

A. Plans and Specifications

The Orleans WWTF design will require detailed Contract Documents (plans and specifications) for public bidding. The plans will be plotted on 24-inch by 36-inch vellums that will be reproduced for bidding. The specifications will be printed on 8-1/2 inch by 11-inch paper that would be reproduced for bidding. The specifications will include the MassDEP requirements for projects funded by the Massachusetts SRF Loan Program.

Table 18 shows a preliminary list of drawings and

Table 19 shows a preliminary list of specifications for the WWTF. These lists will be updated as the final design proceeds toward completion.

Table 18: Preliminary List of Drawings

Drawing No.	Drawing Title	Sheet No.
General		
--	Cover	1
--	Index	2
Site		
LA-1	Existing Conditions Plan	3
LA-2	Layout Plan	4
LA-3	Grading and Drainage Plan	5
LA-4	Effluent Disposal Area Plan	6
LA-5	Effluent Disposal System Section and Details	7
LA-6	Site Construction Details	8
LA-7	Site Construction Details	9
LA-8	Environmental Details I	10
LA-9	Environmental Details II	11
LA-10	Environmental Details III	12
Architectural		
A-1	Abbreviations and Symbols	13
A-2	Building Basement and Ground Level Plans	14
A-3	Building Elevations	15
A-4	Building Sections	16
A-5	Room Finish Schedule, Door Schedule and Details	17
A-6	Miscellaneous Schedules and Details	18
Structural		
S-1	Building and Tank Foundation Plans	19
S-2	Building and Tank Ground Floor Plans	20
S-3	Roof Framing Plan and Details	21
S-4	Building Sections	22
S-5	Building Details	23
S-6	Tank Sections	24
S-7	Tank Details	25

Drawing No.	Drawing Title	Sheet No.
GS-1	Notes and Details I	26
GS-2	Notes and Details II	27
Mechanical		
M-1	Abbreviations and Symbols,	28
M-2	Hydraulic Profile and Flow Schematic	29
M-3	Yard Piping	30
M-4	Basement Plans	31
M-5	Ground Floor Plans	32
M-6	Basement Sections	33
M-7	Ground Floor Sections	34
M-8	Details and Schematics I	35
M-9	Details and Schematics II	36
M-10	General Mechanical Details I	37
M-11	General Mechanical Details II	38
M-12	Force Main Plan and Profile – Number of Drawings TBD	39
M-24	Flow Diversion Structure Plan and Section	49
HVAC		
HV-1	Notes, Legends and Abbreviations	50
HV-2	Basement and Ground Floor Plan	51
HV-3	Legends, Schedules, and Details	52
Plumbing		
P-1	Notes, Legends and Abbreviations	53
P-2	Basement and Ground Floor Plan	54
P-3	Legend, Schedule, and Details	55
Electrical		
E-1	Legend and General Notes	56
E-2	Site Plan (1” = 20’)	57
E-3	Single Line Diagrams and Schematics I	58
E-4	Single Line Diagrams and Schematics II	59
E-5	Control Wiring Diagrams I	60
E-6	Control Wiring Diagrams II	61
E-7	Block Wiring Diagrams I	62
E-8	Block Wiring Diagrams II	63
E-9	Conduit and Panel Board Schedules and Details	64
E-10	Fire and Security Riser Diagram	65
E-11	Duct Bank Sections and Details	66
E-12	Lighting – Basement and Ground Floor Plans	67
E-13	Power – Basement and Ground Floor Plans	68

Drawing No.	Drawing Title	Sheet No.
Instrumentation		
I-1	Legend, Symbols and Notes	69
I-2	PLC Network Diagrams	70
I-3	Instrument Installation Details	71

Table 19: Preliminary List of Specifications

Section	Title
Section 00001	Title Sheet
Section 00003	Table of Contents
BIDDING REQUIREMENTS, CONTRACT FORMS AND CONDITIONS OF THE CONTRACT	
Section 00005	Invitation to Bid
Section 00100	Instructions and Information for Bidders
Section 00300	Form for General Bid
Section 00305	Commonwealth of Massachusetts DCAM Update Statement
Section 00310	Bid Bond
Section 00350	Form for Subbid
Section 00375	Affidavit
Section 00420	Subcontract
Section 00430	Notice of Award
Section 00500	Form for Agreement
Section 00600	Payment Bond
Section 00610	Performance Bond
Section 00650	Notice to Proceed
Section 00700	General Conditions
Section 00852	Special Conditions - General
Section 00855	Special Conditions - Commonwealth of Massachusetts
Section 00858	Special Conditions - Permits and Licenses
Section 00859	Special Conditions – Massachusetts Equal Employment Opportunity
Section 00862	Special Conditions - MassDEP Policy Memoranda
Section 00905	Change Order Form
Section 00945	Certificate of Substantial Completion
Section 00950	Waiver of Liens
Section 00960	Certificate of Final Payment and Completion of Work
Section 00965	Transfer of Title

Section	Title
	TECHNICAL SPECIFICATIONS
DIVISION 1 - GENERAL REQUIREMENTS	
Section 01020	Allowances
Section 01025	Measurement and Payment
Section 01030	Special Requirements
Section 01090	Reference Standards
Section 01140	Environmental Protection
Section 01310	Miscellaneous Testing and Soil Data
Section 01500	Temporary Facilities
Section 01570	Traffic Management and Maintenance
Section 01640	Special Mechanical and Electrical Equipment Requirements
DIVISION 2 - SITE WORK	
Section 02100	Site Preparation
Section 02220	Earthwork
Section 02440	Site Improvements
Section 02444	Chain Link Fence and Gates
Section 02483	Planting Operations
Section 02485	Loaming and Seeding
Section 02503	Paving, Curbing and Sidewalks
Section 02720	Storm Drainage Piping
Section 02725	Manholes, Catch Basins, Handholes, and Pull Boxes
DIVISION 3 – CONCRETE	
Section 03100	Concrete Formwork
Section 03200	Concrete Reinforcement
Section 03250	Concrete Specialties
Section 03300	Cast-In-Place Concrete
Section 03305	Concrete Repair and Surfacing Products
Section 03345	Concrete Placing, Curing and Finishing
Section 03604	Non-Shrink Grout
DIVISION 4 - MASONRY	
Section 04100	Masonry

Section	Title
DIVISION 5 – METAL WORK	
Section 05120	Structural Steel
Section 05140	Aluminum Tank Covers
Section 05310	Metal Roof Deck
Section 05400	Cold-Formed Metal Framing
Section 05500	Miscellaneous Metal Work
DIVISION 6 – WOOD AND PLASTIC	
Section 06100	Carpentry
Section 06192	Prefabricated Wood Trusses
Section 06160	Sheathing
Section 06200	Finish Carpentry
Section 06700	Fiberglass Fabrications
Section 06800	Fiberglass Covers and Appurtenances
Section 06900	Fiberglass Weirs and Baffles
DIVISION 7 – THERMAL AND MOISTURE PROTECTION	
Section 07156	Waterproofing and Dampproofing
Section 07210	Building Insulation
Section 07240	Exterior Insulation and Finish System
Section 07311	Asphalt Shingles
Section 07317	Wood Shingles
Section 07400	Metal Roofing, Siding and Flashing
Section 07900	Sealants and Firestopping
DIVISION 8 – DOORS AND WINDOWS	
Section 08100	Metal Doors and Frames
Section 08220	Fiberglass Reinforced Plastic Doors and Frames
Section 08331	Rolling Metal Doors
Section 08510	Steel Windows
Section 08700	Finish Hardware
Section 08800	Glass and Glazing
DIVISION 9 - FINISHES	
Section 09260	Gypsum Drywall Ceilings
Section 09310	Ceramic Tile and Quarry Tile
Section 09510	Acoustical Ceilings

Section	Title
Section 09650	Resilient Flooring
Section 09661	Liner for Chemical Containment Areas
Section 09900	Painting
DIVISION 10 - SPECIALTIES	
Section 10200	Louvers
Section 10420	Plaque
Section 10440	Signs
Section 10475	Emergency and Miscellaneous Equipment
Section 10520	Fire Extinguishers
Section 10800	Restroom Equipment
Section 10965	Loading Dock Bumpers
DIVISION 11 - EQUIPMENT	
Section 11221	Submersible Mixers
Section 11286	Sluice Gates, Slide Gates and Operators
Section 11310	Centrifugal Pumps
Section 11315	Double Disc Sludge Pumps
Section 11317	Sump Pumps
Section 11318	Rotary Lobe Pumps
Section 11319	Plant Water System
Section 11340	Variable Frequency Drives
Section 11345	Chemical Preparation and Feed Equipment
Section 11347	Humidification and Exhaust Fan System
Section 11348	Odor Control System
Section 11350	Ultraviolet Disinfection Equipment
Section 11371	Positive Displacement Air Blower Equipment
Section 11373	Sequencing Batch Reactors
Section 11374	Effluent Filtration Equipment
Section 11375	Air Diffuser Systems
Section 11380	Wastewater Samplers
DIVISION 12 - FURNISHINGS	
Section 12300	Laboratory Furnishings
Section 12670	Entrance Floor Mats
Section 12700	Furniture

Section	Title
DIVISION 13 - SPECIAL CONSTRUCTION	
Section 13300	Instrumentation and Control System
Section 13350	Field Instruments
Section 13400	Supervisory Control and Data Acquisition (SCADA) System
Section 13500	Security Surveillance System
Section 13768	Fiber Optic Media
DIVISION 14 - CONVEYING SYSTEMS	
Section 14600	Monorail and Hoisting Equipment
DIVISION 15 - MECHANICAL	
Section 15050	Mechanical General Conditions
Section 15080	Mechanical Insulation
Section 15100	Process Piping
Section 15195	Natural Gas Piping System
Section 15300	Fire Protection
Section 15400	Plumbing Systems
Section 15500	Heating, Ventilating and Air Conditioning
Section 15950	HVAC Testing, Adjusting and Balancing
DIVISION 16 - ELECTRICAL	
Section 16050	Electrical General Conditions
Section 16071	Seismic Controls for Electrical Work
Section 16085	Miscellaneous Equipment
Section 16120	Wires and Cables
Section 16130	Raceways and Fittings
Section 16140	Photovoltaic System
Section 16160	Panelboards
Section 16402	Underground Systems
Section 16426	Metal-Enclosed Drawout Switchgear-Low Voltage
Section 16450	Grounding System
Section 16500	Lighting System
Section 16601	Lighting Protection
Section 16612	Engine Generator
Section 16721	Fire Alarm System
Section 16760	Telecommunication Systems
Section 16920	Motor Control Centers

Section	Title
Section 16921	Switchboards
Section 16922	Electrical Power System Studies
Section 16924	Electrical Power Commissioning

B. Permits

Table 20 identifies the permits and approvals that are likely to be required for construction of the Orleans WWTF. This list will be updated as the final design proceeds toward completion.

Table 21: Preliminary List of Permits

Agency Name	Permit
Orleans Building Department	Building Permit (by Construction Contractor)
Orleans Site Plan Review Committee	Certificate of Appropriateness
Orleans Conservation Commission	Wetlands Notice of Intent/Order of Conditions *
Massachusetts Historical Commission	Certificate of Appropriateness
Old's Kings Highway Historic District	Certificate of Appropriateness
MassDEP	Water Quality Permit *
MassDEP	Groundwater Discharge Permit
MassDEP	Plan and Specification Approval
Massachusetts Natural Heritage	Conservation Permit*
U.S. Army Corps of Engineers	Programmatic General Permit *
U.S. EPA	NPDES Permit for construction dewatering permit *

* By Construction Contractor

C. Preliminary Schedule

Table 22 shows the anticipated schedule to implement the construction of the Orleans WWTF.

Table 23: Preliminary Schedule

Task		Duration (Months)
Prepare Draft Plans and Specifications		6 to 9
Town and MassDEP Review		3 to 4
Finalize Plans and Specifications		1
Obtain Permits		3 to 7
Construction		12 to 18
Startup and Testing		2 to 3
	Total	27 to 42

Figures and Table

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Figure 7: Headworks Layout – MBR Option

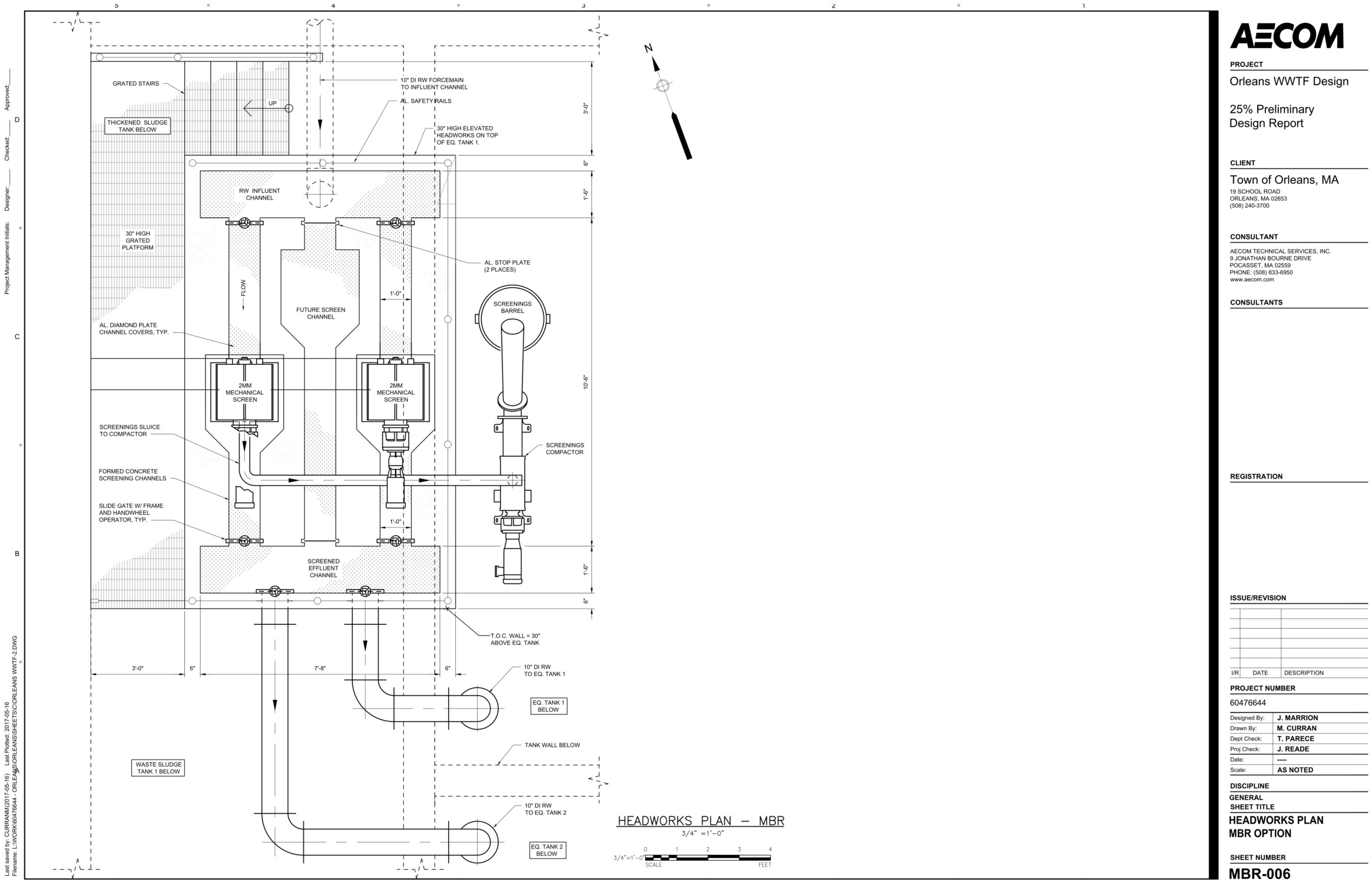

Figure 8: Headworks Layout – SBR Option

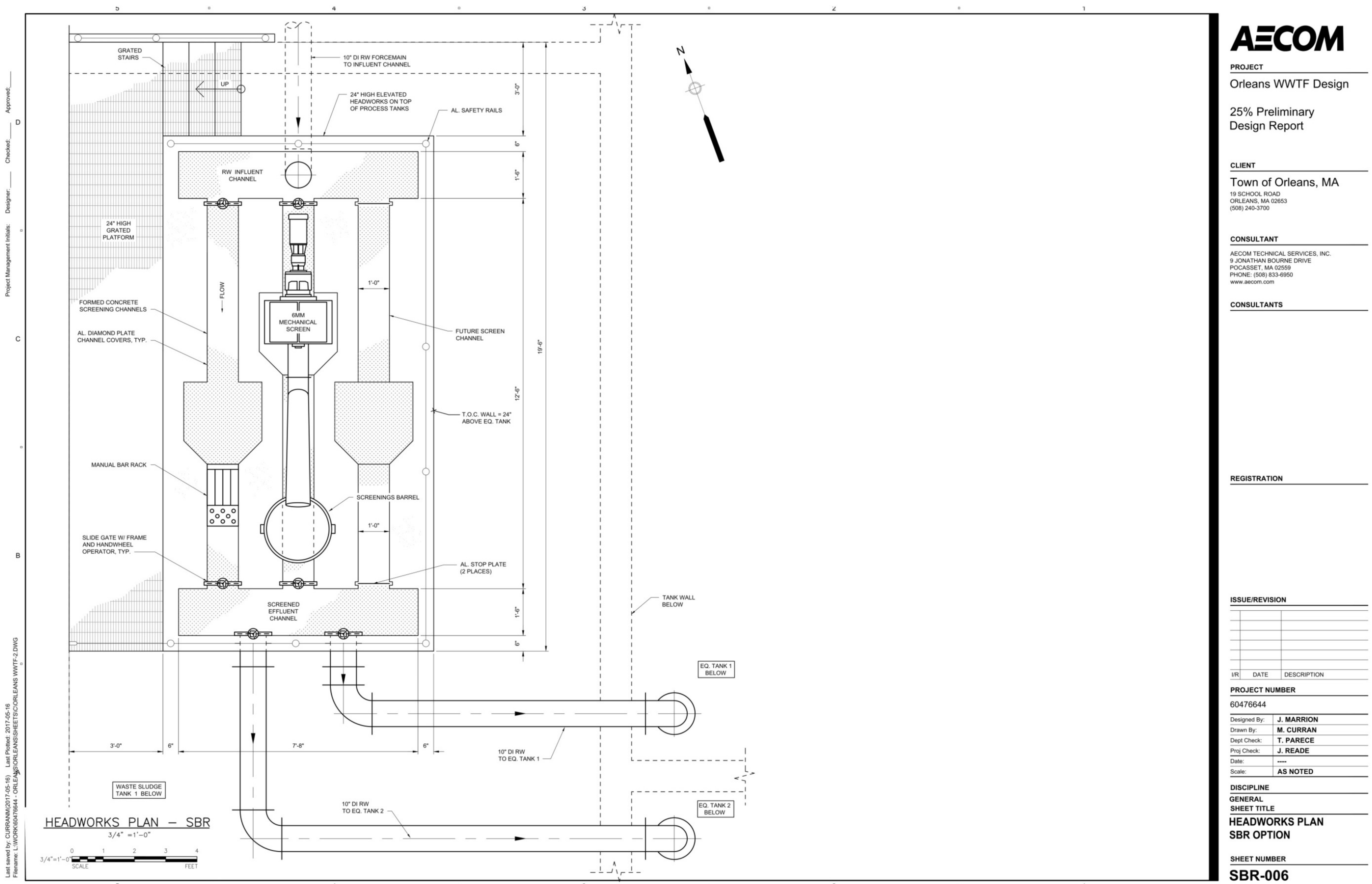

Figure 9: Process Flow Diagram for MBR Option

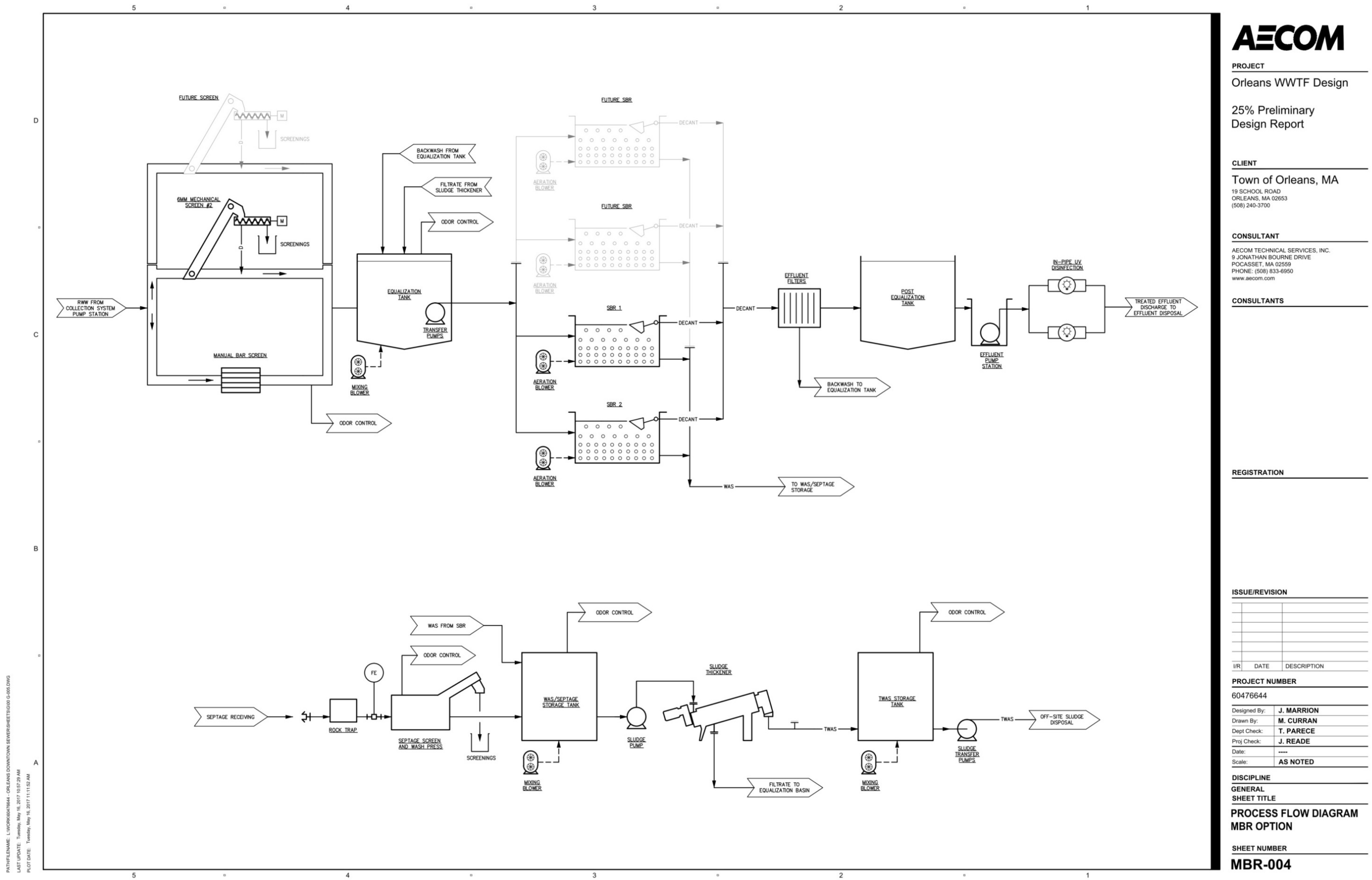

Figure 10: Process Flow Diagram for SBR Option

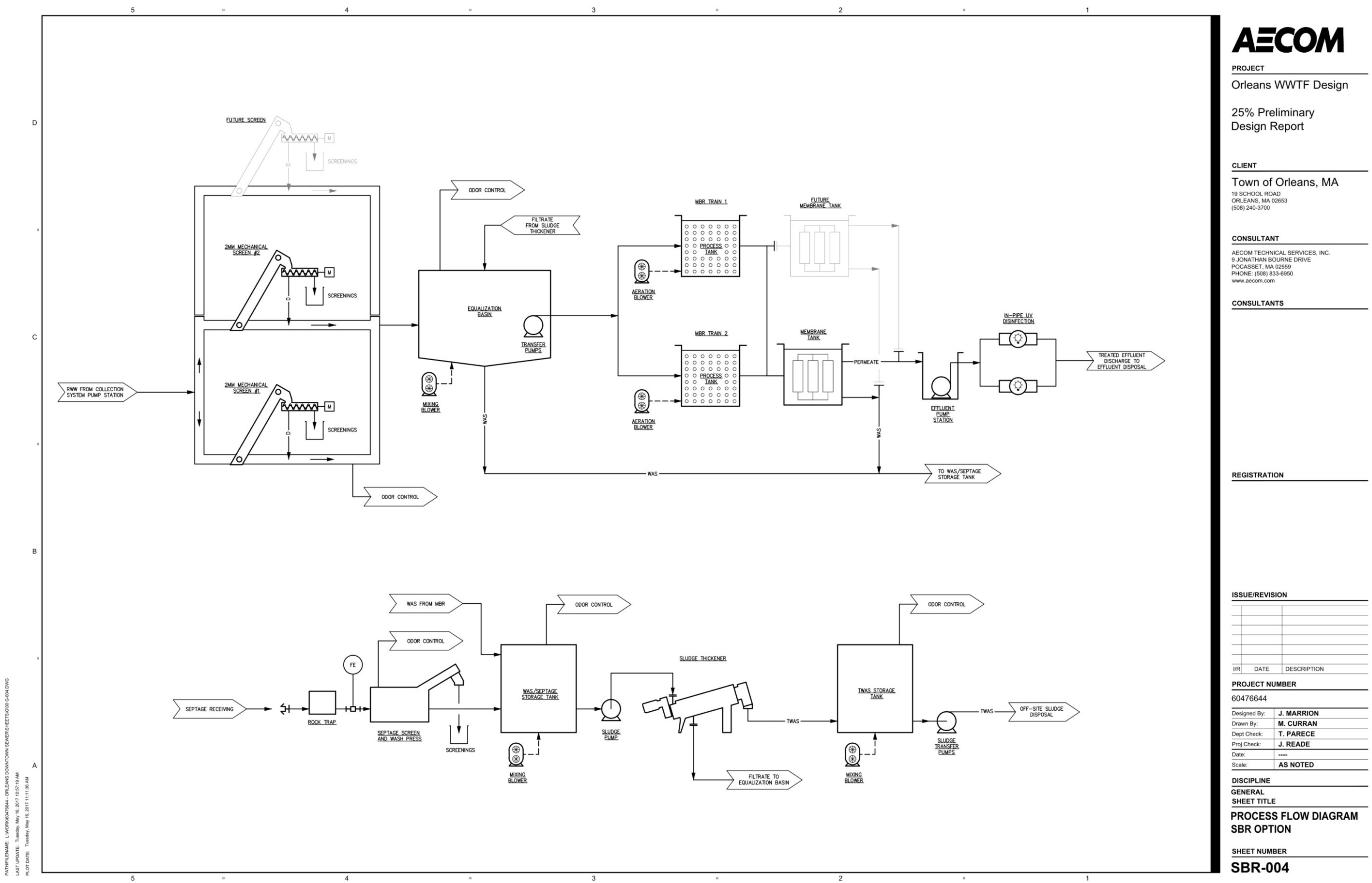

Figure 11: Site Plan – MBR Option

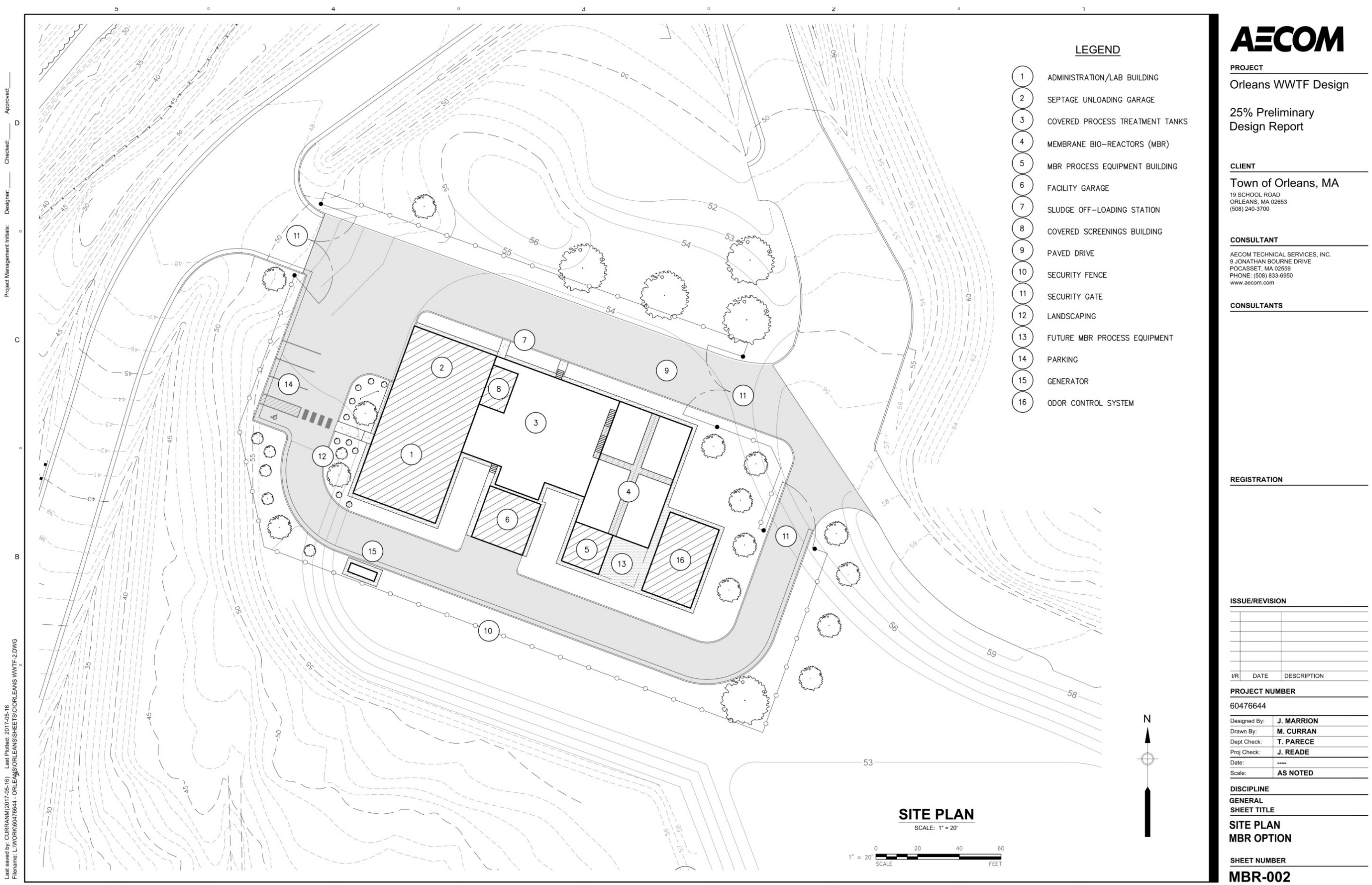

Figure 12: Floor Plan & Section – MBR Option

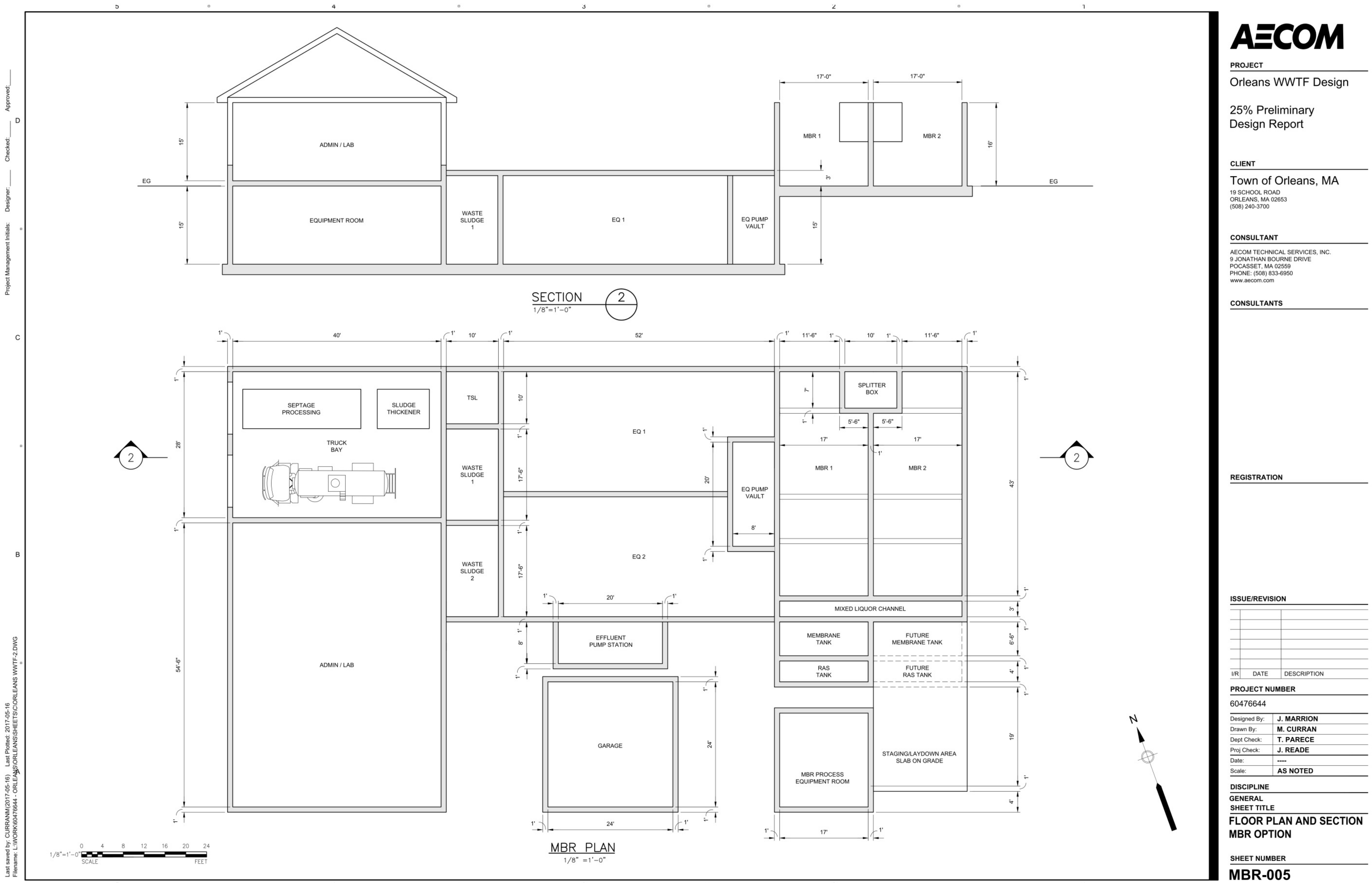

Figure 13: Elevation Views – MBR Option

Figure 14: Hydraulic Profile – MBR Option

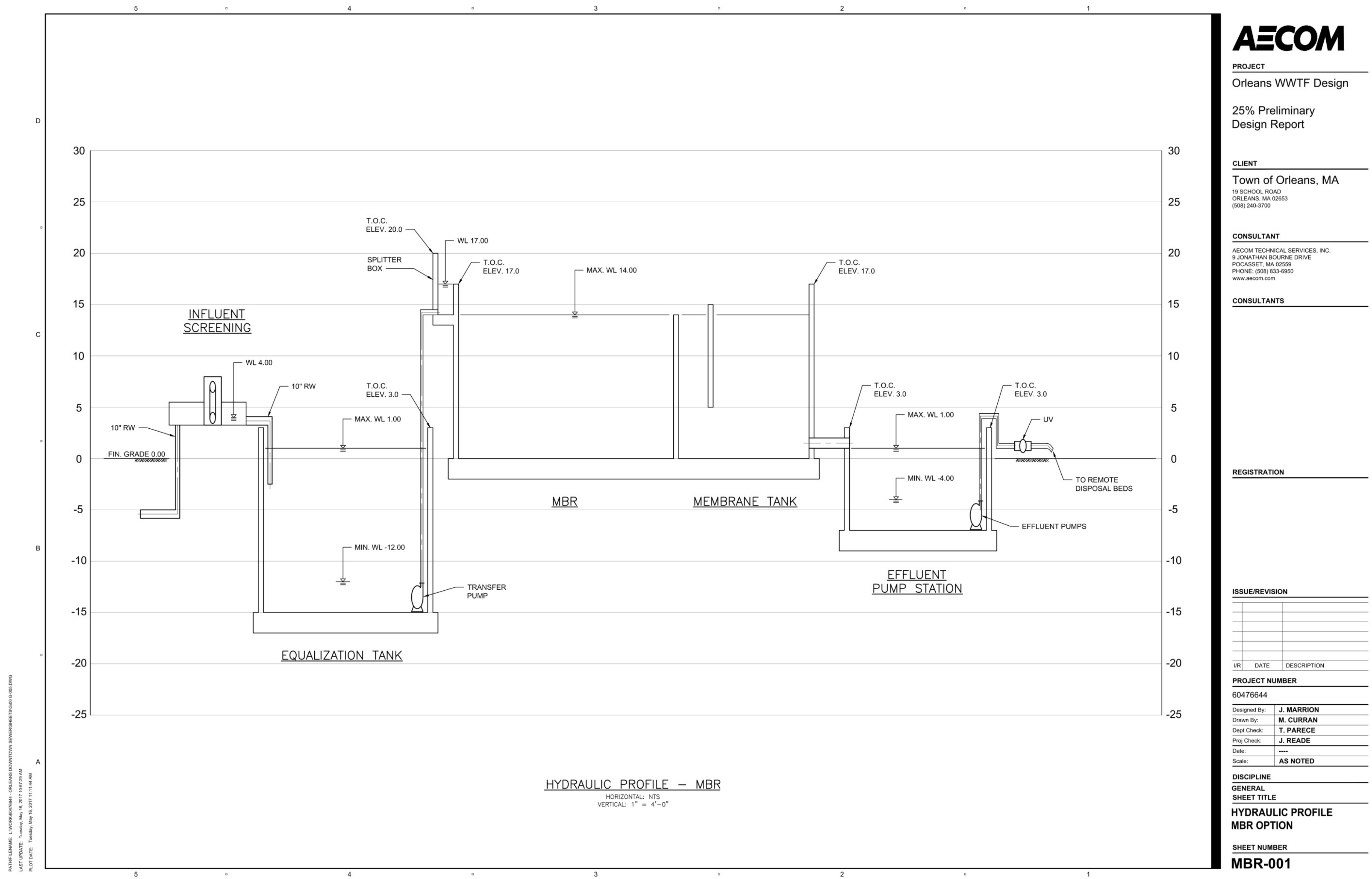

Figure 15: Site Plan – SBR Option

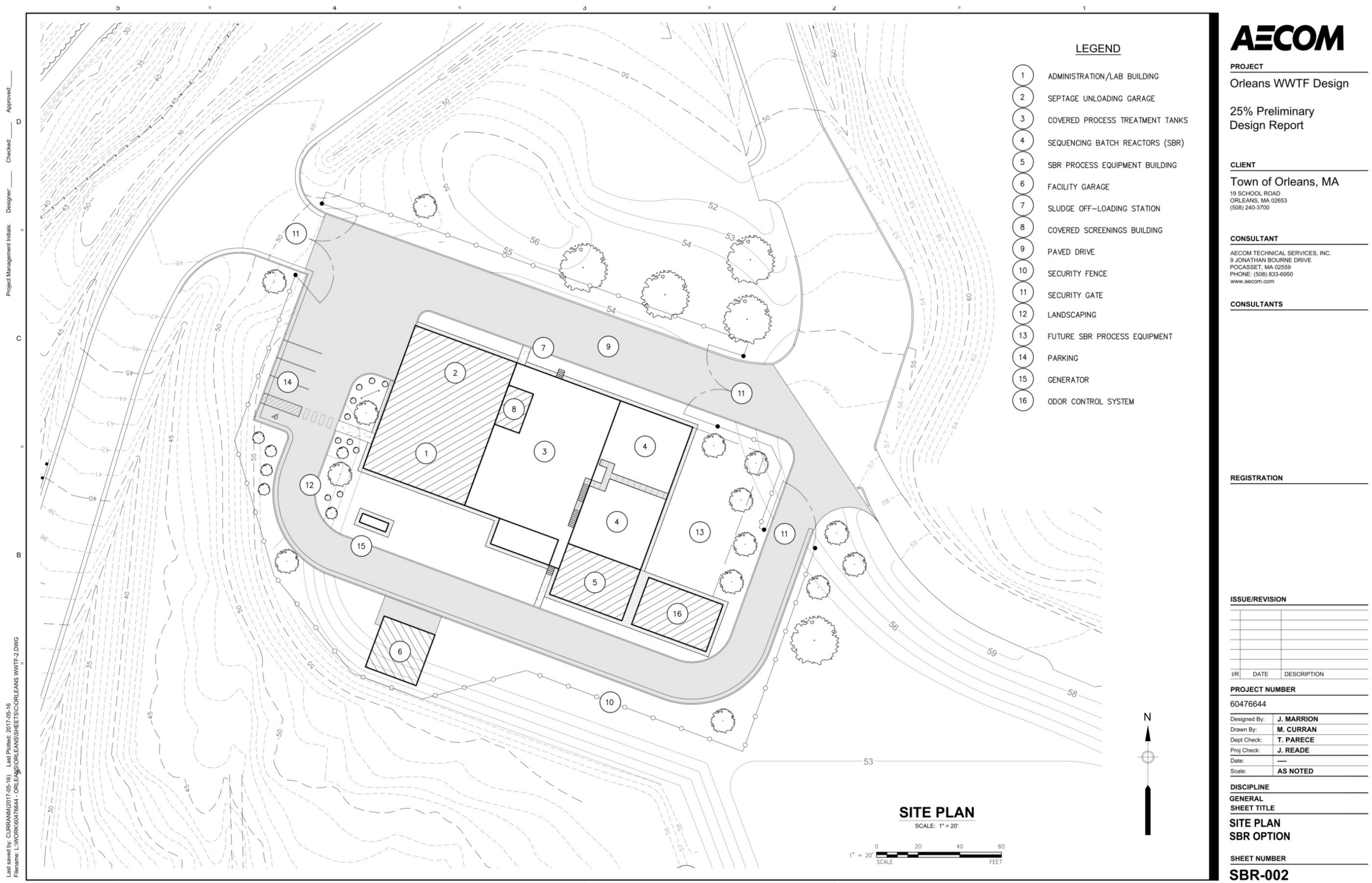

Figure 16: Floor Plan & Section – SBR Option

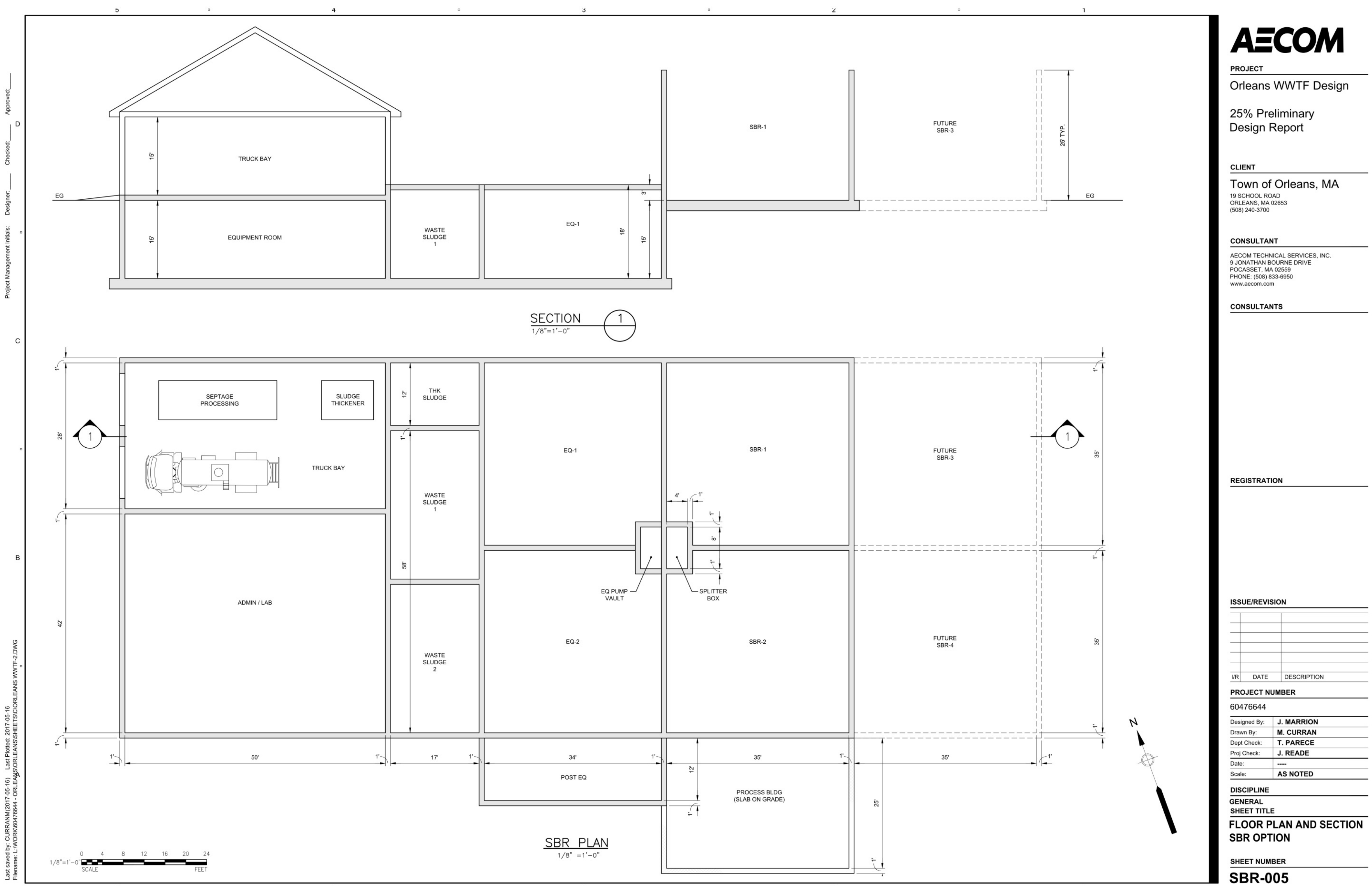

Figure 17: Elevations – SBR Option

Figure 18: Hydraulic Profile – SBR Option

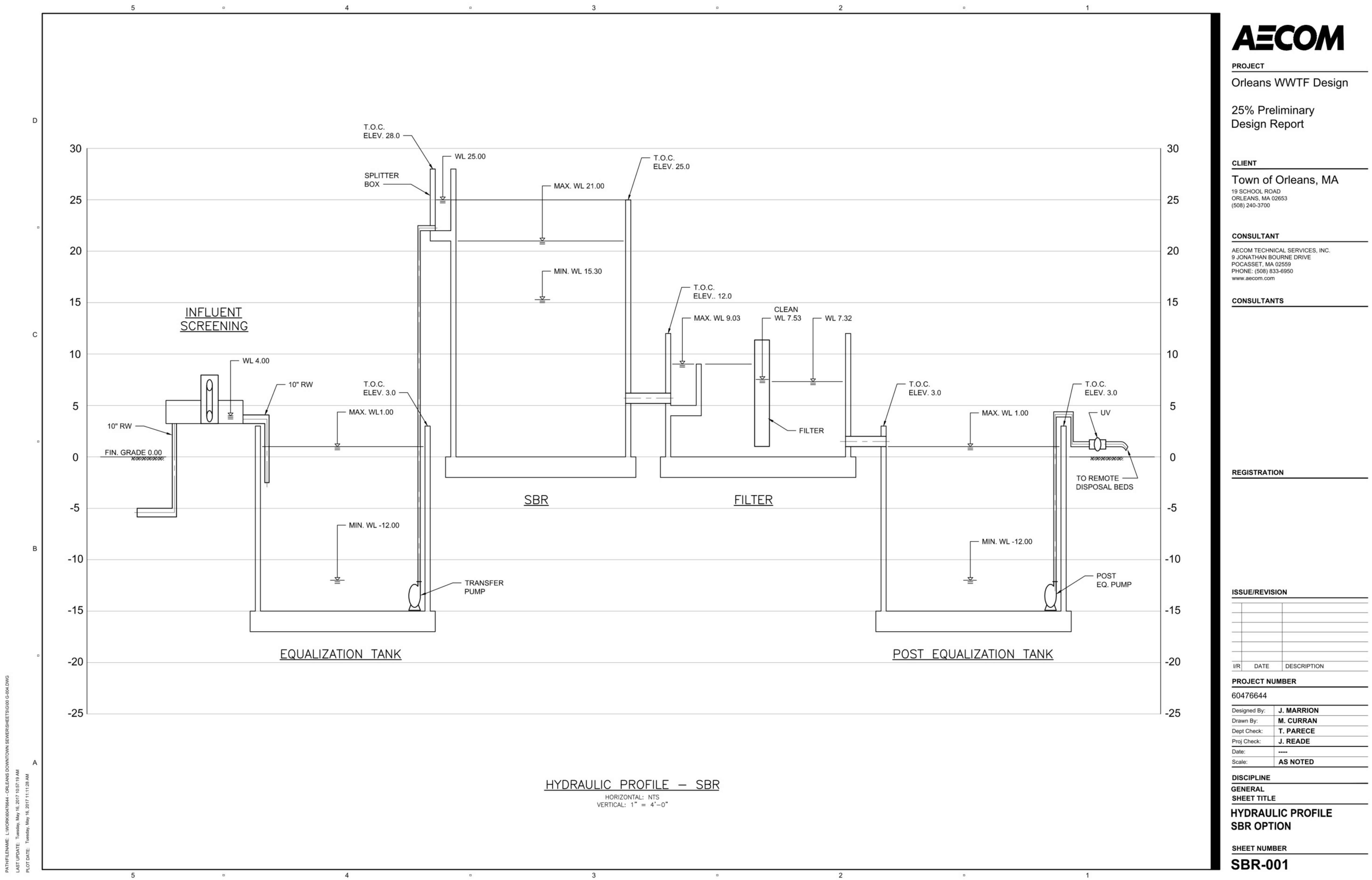

Table 24: Life Cycle Cost Analysis of MBR and SBR Options

Current Year Cost

	SBR	MBR	
Capital Cost, $	$ 14,030,000	$ 14,275,000	<- Escalation to construction mid-point already included
O&M Cost-Chems, $/yr	$ -	$ 700	
O&M Cost-Power, $/yr	$ 27,800	$ 27,525	
O&M Cost Replacement, $	$ -	$ 120,000	<- Membrane replacement in year 10 (MBR only)

Note: O&M costs that are assumed to be equivalent between the two options (labor, general mechancial equipment upkeep, facility heating, etc.) are not included in the analysis

General Inflation Rate	3.0%
Electricity Inflation Rate	3.3%
Discount Rate	1.5%

MBR

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	0	1	2	3	4	5	6	7	8	9	10
Cap Cost	$ 14,275,000										
O&M Cost-Chems, $		$ 788	$ 811	$ 836	$ 861	$ 887	$ 913	$ 941	$ 969	$ 998	$ 1,028
O&M Cost-Power, $		$ 31,379	$ 32,423	$ 33,503	$ 34,619	$ 35,772	$ 36,963	$ 38,194	$ 39,465	$ 40,780	$ 42,138
O&M Cost-Replacement, $		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 176,224
Total Annual Cost	$ 14,275,000	$ 32,166	$ 33,235	$ 34,339	$ 35,480	$ 36,658	$ 37,876	$ 39,134	$ 40,434	$ 41,778	$ 219,390
Discounted Annual Cost. $	$ 14,275,000	$ 30,293	$ 30,833	$ 31,383	$ 31,943	$ 32,513	$ 33,093	$ 33,683	$ 34,284	$ 34,896	$ 180,521

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	11	12	13	14	15	16	17	18	19	20
Cap Cost										
O&M Cost-Chems, $	$ 1,059	$ 1,091	$ 1,123	$ 1,157	$ 1,192	$ 1,227	$ 1,264	$ 1,302	$ 1,341	$ 1,382
O&M Cost-Power, $	$ 43,541	$ 44,991	$ 46,489	$ 48,037	$ 49,637	$ 51,290	$ 52,997	$ 54,762	$ 56,586	$ 58,470
O&M Cost-Replacement, $	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Annual Cost	$ 44,600	$ 46,081	$ 47,612	$ 49,194	$ 50,828	$ 52,517	$ 54,262	$ 56,064	$ 57,927	$ 59,852
Discounted Annual Cost. $	$ 36,152	$ 36,797	$ 37,453	$ 38,121	$ 38,801	$ 39,494	$ 40,198	$ 40,915	$ 41,645	$ 42,388

LCC (20yr)	$ 15,100,000	<--- Does not include O&M costs that are assumed to be equivalent between the two options (labor, general mechancial equipment upkeep, facility heating, etc.) are not included in the analysis

SBR

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	0	1	2	3	4	5	6	7	8	9	10
Cap Cost	$ 14,030,000										
O&M Cost-Chems, $		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
O&M Cost-Power, $		$ 31,692	$ 29,682	$ 30,671	$ 31,692	$ 32,747	$ 33,838	$ 34,965	$ 36,129	$ 37,332	$ 38,575
O&M Cost-Replacement, $		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Annual Cost,$	$ 14,030,000	$ 31,692	$ 29,682	$ 30,671	$ 31,692	$ 32,747	$ 33,838	$ 34,965	$ 36,129	$ 37,332	$ 38,575
Discounted Annual Cost. $	$ 14,030,000	$ 29,846	$ 27,538	$ 28,031	$ 28,533	$ 29,044	$ 29,565	$ 30,094	$ 30,634	$ 31,182	$ 31,741

Year	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	11	12	13	14	15	16	17	18	19	20
Cap Cost										
O&M Cost-Chems, $	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
O&M Cost-Power, $	$ 39,860	$ 41,187	$ 42,559	$ 43,976	$ 45,440	$ 46,953	$ 48,517	$ 50,133	$ 51,802	$ 53,527
O&M Cost-Replacement, $	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Annual Cost,$	$ 39,860	$ 41,187	$ 42,559	$ 43,976	$ 45,440	$ 46,953	$ 48,517	$ 50,133	$ 51,802	$ 53,527
Discounted Annual Cost. $	$ 32,310	$ 32,889	$ 33,478	$ 34,078	$ 34,688	$ 35,310	$ 35,942	$ 36,586	$ 37,242	$ 37,909

LCC (20yr)	$ 14,700,000	<--- Does not include O&M costs that are assumed to be equivalent between the two options (labor, general mechancial equipment upkeep, facility heating, etc.) are not included in the analysis

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Appendix A – Preliminary Detailed Cost Estimates

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01:49 PM

AECOM Water
Construction Cost Estimate
WWTF - SBR vs MBR
Preliminary Design Estimate (25%)
Orleans, MA

JOB NO : 60476644.10.1.C
DATE : May 18, 2017
LOCATION : Orleans, MA
PREPARED BY: R Mastrogiacomo
CHECKED BY: J. Reade

CLIENT : Orleans, MA
PROJECT : WWTP Improvements
ACCURACY: ± 30 %
ENR CCI: 10692
CAPACITY: 0.2 MGD

****

G R A N D S U M M A R Y

OPTION	DESCRIPTION	TOTAL
	WWTF	
1	SBR Structures	$ 14,025,418
2	MBR Structures	$ 14,275,231

JOB #: 60476644.10.1.C
DATE: May 18, 2017
LOCATION: Orleans, MA
PREPARED BY: R Mastrogiacomo

AECOM Water
Construction Cost Estimate
WWTF - SBR vs MBR
Preliminary Design Estimate (25%)

CLIENT : Orleans, MA
PROJECT : WWTP Improvements
ACCURACY: ± 30 %
ENR. INDEX 10692

ACCOUNT NO.	DESCRIPTION	QUANTITY	UN	MANHOURS MHR/ UNIT	MANHOURS TOTAL MH	MATERIAL UNIT COST	MATERIAL TOTAL MATL	LABOR WAGE RATE	LABOR TOTAL LABOR	EQUIPMENT UNIT RATE	EQUIPMENT TOTAL EQUIP	TOTAL DIRECT COST
	THIS CONSTRUCTION COST IS BASED ON:											
	1. 25% Preliminary Design Drawings											
	2. PRICING IS BASED ON 2nd QUARTER 2017.											
	3. CONTINGENCY SHOWN IS CONTRACTOR CONTINGENCY BASED ON LEVEL OF DESIGN, OWNER CONTINGENCY NOT INCLUDED											
	4. THE SOILS AT THE SITE ARE SUITABLE FOR STANDARD EXCAVATING METHODS.											
	5. ESCALATION CONSIDERED @ 3.50% /year											
	6. IN PROVIDING OPINION OF PROBABLE CONSTRUCTION COST, THE CLIENT UNDERSTANDS THAT AECOM HAS NO CONTROL OVER THE COST OR AVAILABILITY OF LAB EQUIPMENT OR MATERIALS OR OVER MARKET CONDITIONS OR THE CONTRACTOR'S METHOD OF PRICING. AECOM MAKES NO WARRANTY, EXPRESS OR IMPLIED THAT BIDS WILL NOT VARY FROM THIS ESTIMATE.											
	7. Average wage rate calculated from 2016 Means Labor rates for Construction Industry (ENR 10,092). Used Pittsfield, MA ($60.87) escalated at										5.9%	
	to the time of the estimate and added 25.9% for:											
	SS Tax	7.65%										
	Workers Comp Ins	11.60%										
	Builders Risk	0.44%										
	Other Negotiated fringe	1.60%										
	Federal Unemployment Ins	0.14%										
	State Unemployment Ins	2.93%										
	General Liability Insurance	1.57%										
	TOTAL	25.9%										
	AVERAGE Labor Rate ---->	**$81.21**										
	Start Const	10/01/18										
	End Const	04/01/21		12/31/19	<--- Mid-point Construction							
	Final Completion	02/01/21										
	Contingency :	**30%**										
	Overhead & Profit Set at:	**22%**										
	Owner's Contingency	**5%**										

OPTION Number	DESCRIPTION	QUANTITY	UN	MANHOURS MHR/ UNIT	MANHOURS TOTAL MH	MATERIAL UNIT COST	MATERIAL TOTAL MATL	LABOR WAGE RATE	LABOR TOTAL LABOR	EQUIPMENT UNIT RATE	EQUIPMENT TOTAL EQUIP	TOTAL DIRECT COST
1	***SBR Structures***											
	Civil											
	Sitework Landscaping	1	AL	500.00	500	10,000.00	10,000	$81.21	40,605	25,000.00	25,000	$75,605
	Roadway Paving	1,900	SY	0.04	76	15.00	28,500	$81.21	6,172	2.00	3,800	$38,472
	Granite Curbing	1,000	LF	0.20	200	14.00	14,000	$81.21	16,242	2.00	2,000	$32,242
	Fencing	900	LF	0.10	90	20.00	18,000	$81.21	7,309	1.25	1,125	$26,434
	Site Electrical	1	AL	500.00	500	50,000.00	50,000	$81.21	40,605	1,000.00	1,000	$91,605
	Excavation for ADMIN, WASTE SLUDGE & EQ TANKS (18' Depth)	5,493	CY	0.20	1,099	0.00	0	$81.21	89,213	2.00	10,985	$100,198
	Bedding	284	CY	0.20	57	12.00	3,407	$81.21	4,611	2.00	568	$8,585
	Backfill	475	CY	0.20	95	0.00	0	$81.21	7,710	2.00	949	$8,659
	Excavation for SOG (4' Depth)	528	CY	0.20	106	0.00	0	$81.21	8,576	2.00	1,056	$9,632
	Controlled Fill	528	CY	0.20	106	12.00	6,336	$81.21	8,576	2.00	1,056	$15,968
	Structural											
	Base Slab (73' x 105') + (36' x 13') 24" Thick	602.4	CY	7.00	4,217	170.00	102,416	$81.21	342,475	0.00	0	$444,891
	Slab on Grade (SBR 99' x 36') 24" Thick	264.0	CY	7.00	1,848	170.00	44,880	$81.21	150,078	0.00	0	$194,958
	Slab on Grade (Process Bldg 25' x 35') 24" Thick	64.8	CY	7.00	454	170.00	11,019	$81.21	36,846	0.00	0	$47,864
	Concrete Walls (Truck Bay & Admin - 15' high, 22" thick)	299.4	CY	8.00	2,396	180.00	53,900	$81.21	194,545	0.00	0	$248,445
	Concrete Walls (Waste Sludge Tanks & EQ tanks - 17' high, 22" thick)	434.0	CY	8.00	3,472	180.00	78,124	$81.21	281,980	0.00	0	$360,105
	Concrete Walls (SBR tanks - 25' high)	312.3	CY	8.00	2,499	180.00	56,222	$81.21	202,927	0.00	0	$259,149
	Ground Slab (Truck Bay & Admin - 70' x 50')	237.7	CY	7.00	1,664	170.00	40,401	$81.21	135,101	0.00	0	$175,502
	Ground Slab (Waste Sludge Tanks & EQ Tanks - 71' x 17' + 84' x34')	275.9	CY	7.00	1,931	170.00	46,900	$81.21	156,833	0.00	0	$203,733
	Concrete Columns (20" diameter, 15' grid, say 1.25 Cy/column))	10	EA	15.00	150	275.00	2,750	$81.21	12,182	31.00	310	$15,242
	Hand Rail	200.0	LF	0.20	40	75.00	15,000	$81.21	3,248	1.00	200	$18,448
	Slab on Grade (Pos Eq Tank 12' x 8') 16" Thick	4.7	CY	7.00	33	170.00	806	$81.21	2,695	0.00	0	$3,501
	Headworks											
	Base Slab (Using top of EQ Tanks)	0.0	CY	7.00	0	170.00	0	$81.21	0	0.00	0	$0
	Eq tanks Column Support	1.0	AL	40.00	40	5,000.00	5,000	$81.21	3,248	1,000.00	1,000	$9,248
	Concrete Walls (19.5 x 11.67)	7.7	CY	8.00	62	180.00	1,385	$81.21	5,000	0.00	0	$6,386
	Concrete Fill	6.6	CY	4.00	26	110.00	726	$81.21	2,143	25.00	165	$3,033
	Wood Building over Headworks Channel (20' x 12') w/XP Elec	240.0	SF	1.00	240	50.00	12,000	$81.21	19,491	3.00	720	$32,211
	Grating	60.0	SF	0.10	6	30.00	1,800	$81.21	487	0.35	21	$2,308
	Grated Stairs	1.0	AL	40.00	40	3,000.00	3,000	$81.21	3,248	0.00	0	$6,248
	Diamond Plate	76.5	SF	0.40	31	12.00	918	$81.21	2,485	2.00	153	$3,556
	Hand Rail	56.0	LF	0.20	11	75.00	4,200	$81.21	910	1.00	56	$5,166
	H2s Coating for Sludge Tanks	3,774.0	SF	0.07	264	1.50	5,661	$81.21	21,454	0.00	0	$27,115
	Splitter box upstream of headworks (assume 6'Dx10'x7')	1	EA	100.00	100	15,000.00	15,000	$81.21	8,121	1,000.00	1,000	$24,121
	Architectural											
	Exterior											
	12" CMU w/4" Brick Façade w/Insulation (truck Bay/Admin)	3,600	SF	0.37	1,332	10.00	36,000	$81.21	108,173	0.00	0	$144,173
	12" CMU w/4" Brick Façade w/Insulation (Process Bldg, 20'h)	2,400	SF	0.37	888	10.00	24,000	$81.21	72,115	0.00	0	$96,115
	Roof											
	Shingle Roof (truckBay/Admin)	42	SQ	14.40	605	1,008.00	42,336	$81.21	49,116	72.00	3,024	$94,476
	Insulation (2")	4,200	SF	0.0060	25	0.82	3,444	$81.21	2,047	0.00	0	$5,491
	Shingle Roof (Process Bldg)	10	SQ	14.40	144	1,008.00	10,080	$81.21	11,694	72.00	720	$22,494
	Insulation (2")	1,000	SF	0.0060	6	0.82	820	$81.21	487	0.00	0	$1,307

OPTION Number	DESCRIPTION	QUANTITY	UN	MANHOURS		MATERIAL		LABOR		EQUIPMENT		TOTAL DIRECT COST
				MHR/ UNIT	TOTAL MH	UNIT COST	TOTAL MATL	WAGE RATE	TOTAL LABOR	UNIT RATE	TOTAL EQUIP	
	Garage (24' x 24')	576	SF	0.70	403	85.00	48,960	$81.21	32,744	2.00	1,152	$82,856
	Painting		AL	400.00	0	15,000.00	0	$81.21	0	0.00	0	$0
	Equipment											
	Headworks											
	Preliminary Screening - 6 mm	1	EA	140	140	125,000	125,000	$81.21	11,370	125.00	125	$136,495
	Coarse Bubble Diffusers (EQ Tank, WAS Tank, and TWAS Tank)	1	LS	60	60	34,000	34,000	$81.21	4,873	0.00	0	$38,873
	Equalization Tank Pumps	3	EA	10	30	7,500	22,500	$81.21	2,436	75.00	225	$25,161
	Guide Rail Assemblies for future pumps	2	EA	8	16	800	1,600	$81.21	1,299	0.00	0	$2,899
	SBR	1	LS	500	500	387,500	387,500	$81.21	40,605	3,875.00	3,875	$431,980
	Includes: mixers and assemblies/support, decanter assemblies, transfer pumps, fine bubble diffusers, PD blowers, controls, and instrumentation											
	SBR - Cloth Disk Filter	1	EA	400	400	362,000	362,000	$81.21	32,484	3,620.00	3,620	$398,104
	Effluent Discharge Pumps	3	EA	16	48	13,500	40,500	$81.21	3,898	135.00	405	$44,803
	Guide Rail Assemblies for future pumps	2	EA	16	32	800	1,600	$81.21	2,599	0.00	0	$4,199
	UV (in-pipe)	1	EA	200	200	156,000	156,000	$81.21	16,242	1,560.00	1,560	$173,802
	Admin Building											
	Blowers - 250 scfm	4	EA	20	81	16,545	66,180	$81.21	6,618	160.00	640	$73,438
	Blowers - 650 scfm	2	EA	30	60	23,700	47,400	$81.21	4,873	250.00	500	$52,773
	Septage Receiving	1	EA	600	600	405,000	405,000	$81.21	48,727	6,000.00	6,000	$459,727
	Sludge Thickening - Disk Thickener	1	EA	225	225	181,000	181,000	$81.21	18,272	1,810.00	1,810	$201,082
	RDT Feed Pump	2	EA	18	36	15,000	30,000	$81.21	2,924	150.00	300	$33,224
	Load out Station	1	EA	18	18	15,000	15,000	$81.21	1,462	150.00	150	$16,612
	Thickened Sludge Load Out Pump	2	EA	30	60	25,000	50,000	$81.21	4,873	250.00	500	$55,373
	Plant Water System											
	Plant Water/Distribution Pumps (400 gpm @322', 50 hp)	2	EA	32.00	64	21,500.00	43,000	$81.21	5,197	215.00	430	$48,627
	Controller/Piping	1	AL	120.00	120	20,000.00	20,000	$81.21	9,745	200.00	200	$29,945
					0							
	Odor Control (air from septage receiving garage, headworks building, sludge storage tanks, and EQ tank)	1	EA	380	380	206,000	206,000	$81.21	30,860	2,060.00	2,060	$238,920
	Lab Equipment/Cabinet Allowance	1	AL	450.00	450	60,000.00	60,000	$81.21	36,545	1,000.00	1,000	$97,545
	Equipment Lift	1	AL	120.00	120	20,000.00	20,000	$81.21	9,745	500.00	500	$30,245
	Piping											
	Percentage of Mechanical	15%	%	3,070	461	2,194,280	329,142	$81.21	37,404	22,400	3,360	$369,906
	Electrical											
	Percentage of Project	20%	%	28,489	5,698	3,280,913	656,183	$81.21	462,722	50,395	10,079	$1,128,984
	Diesel Generator w/Acoustical Enclosure (250 KW)	1	AL	125.00	125	100,000.00	100,000	$81.21	10,151	1,000.00	1,000	$111,151
	I&C											
	50% of Electrical	50%	%	5,698	2,849	656,183	328,091	$81.21	231,361	10,079	5,040	$564,492

Subtotal	$7,713,904
22% Contractor, GC, Overhead and Profit	$ 1,697,059
30% Contingency	$ 2,823,289
5% Owner's Contingency	$ 611,713
SUBTOTAL	$12,845,965

OPTION Number	DESCRIPTION	QUANTITY	UN	MANHOURS MHR/ UNIT	TOTAL MH	MATERIAL UNIT COST	TOTAL MATL	LABOR WAGE RATE	TOTAL LABOR	EQUIPMENT UNIT RATE	TOTAL EQUIP	TOTAL DIRECT COST
ESCALATION TO MID-POINT OF CONSTRUCTION		3.5%						2.62	**9.2%**			$ 1,179,453
ASSUMED AT:	**December 31, 2019**	PER YEAR						YEARS	NON-COMPOUNDED RATE			$ 14,025,418

Area Number	DESCRIPTION	QUANTITY	UN	MANHOURS MHR/ UNIT	TOTAL MH	MATERIAL UNIT COST	TOTAL MATL	LABOR WAGE RATE	TOTAL LABOR	EQUIPMENT UNIT RATE	TOTAL EQUIP	TOTAL DIRECT COST
2	***MBR Structures***											
	Civil											
	Sitework Landscaping	1	AL	500.00	500	10,000.00	10,000	$81.21	40,605	25,000.00	25,000	$75,605
	Roadway Paving	1,850	SY	0.04	74	15.00	27,750	$81.21	6,010	2.00	3,700	$37,460
	Granite Curbing	1,000	LF	0.20	200	14.00	14,000	$81.21	16,242	2.00	2,000	$32,242
	Fencing	900	LF	0.10	90	20.00	18,000	$81.21	7,309	1.25	1,125	$26,434
	Site Electrical	1	AL	500.00	500	50,000.00	50,000	$81.21	40,605	1,000.00	1,000	$91,605
	Excavation for ADMIN, WASTE SLUDGE & EQ TANKS (18' Depth)	5,493	CY	0.20	1,099	0.00	0	$81.21	89,213	2.00	10,985	$100,198
	Bedding	284	CY	0.20	57	12.00	3,407	$81.21	4,611	2.00	568	$8,585
	Backfill	475	CY	0.20	95	0.00	0	$81.21	7,710	2.00	949	$8,659
	Excavation for SOG (4' Depth)	247	CY	0.20	49	0.00	0	$81.21	4,006	2.00	493	$4,500
	Controlled Fill	247	CY	0.20	49	12.00	2,960	$81.21	4,006	2.00	493	$7,460
	Excavation for Eff PS Tank	85	CY	0.20	17	0.00	0	$81.21	1,386	2.00	171	$1,557
	Bedding	6	CY	0.20	1	12.00	71	$81.21	96	2.00	12	$179
	Backfill	33	CY	0.20	7	0.00	0	$81.21	539	2.00	66	$605
	Structural											
	Base Slab EQ 1 & 2, WS 1 & 2, TSL (85' x 49') 24" Thick	308.5	CY	7.00	2,160	170.00	52,448	$81.21	175,385	0.00	0	$227,834
	Base Slab Admin/Lab, Truck Bay (80' x 40') 24" thick	237.0	CY	7.00	1,659	170.00	40,296	$81.21	134,750	0.00	0	$175,046
	Slab on Grade (MBR 1 & 2 & MBR EFF, 37' x 48', 24" Th)	131.6	CY	7.00	921	170.00	22,364	$81.21	74,786	0.00	0	$97,151
	Slab on Grade (MBR Tank, RAS Tank, 12' x 19', 24" Th)	16.9	CY	7.00	118	170.00	2,871	$81.21	9,601	0.00	0	$12,472
	Slab on Grade (Laydown Area,20' x 35' +12' x 18', 18" Th)	50.9	CY	7.00	356	170.00	8,651	$81.21	28,929	0.00	0	$37,580
	Ground Slab (Truck Bay & Admin - 80' x40')	237.0	CY	7.00	1,659	170.00	40,296	$81.21	134,750	0.00	0	$175,046
	Ground Slab EQ 1 & 2, WS 1 & 2, TSL (65' x 49') 24" Thick	308.5	CY	7.00	2,160	170.00	52,448	$81.21	175,385	0.00	0	$227,834
	Concrete Walls (Truck Bay & Admin - 15' high, 22" thick)	324.0	CY	8.00	2,592	180.00	58,320	$81.21	210,499	0.00	0	$268,819
	Concrete Walls (EQ 1 & 2, WS 1 & 2, TSL - 18' high, 22" thick)	300.0	CY	8.00	2,400	180.00	54,000	$81.21	194,906	0.00	0	$248,906
	Concrete Walls (MBR, RAS tanks, Mem Tank - 16' high)	248.0	CY	8.00	1,984	180.00	44,640	$81.21	161,122	0.00	0	$205,762
	Concrete Columns (20" diameter, 15' grid, say 1.25 Cy/column))	12	EA	15.00	180	275.00	3,300	$81.21	14,618	31.00	372	$18,290
	Hand Rail	200.0	LF	0.20	40	75.00	15,000	$81.21	3,248	1.00	200	$18,448
	Stand Alone Tank (Eff PS)											
	Base Slab	11.9	CY	7.00	83	170.00	2,015	$81.21	6,737	0.00	0	$8,752
	Concrete Walls	31.1	CY	8.00	249	180.00	5,600	$81.21	20,212	0.00	0	$25,812
	Headworks											
	Base Slab (Using top of EQ Tanks)	114.7	CY	7.00	803	170.00	19,493	$81.21	65,185	0.00	0	$84,679
	Eq tanks Column Support	1.0	AL	34.00	34	4,250.00	4,250	$81.21	2,761	850.00	850	$7,861
	Concrete Walls (8.67 x 14.5')	7.2	CY	8.00	57	180.00	1,287	$81.21	4,646	0.00	0	$5,933
	Concrete Fill	8.7	CY	4.00	35	110.00	954	$81.21	2,816	25.00	217	$3,987
	Wood Building over Headworks Channel (15' x 13') w/XP Elec	195.0	SF	1.00	195	50.00	9,750	$81.21	15,836	3.00	585	$26,171
	Grating	210.0	SF	0.10	21	30.00	6,300	$81.21	1,705	0.35	74	$8,079
	Grated Stairs	1.0	AL	40.00	40	3,000.00	3,000	$81.21	3,248	0.00	0	$6,248
	Diamond Plate	60.5	SF	0.40	24	12.00	726	$81.21	1,966	2.00	121	$2,813
	Hand Rail	35.0	LF	0.20	7	75.00	2,625	$81.21	568	1.00	35	$3,228
	H2s Coating for Sludge Tanks	2,376.0	SF	0.07	166	1.50	3,564	$81.21	13,507	0.00	0	$17,071
	Splitter box upstream of headworks (assume 6'Dx10'x7')	1	EA	100.00	100	15,000.00	15,000	$81.21	8,121	1,000.00	1,000	$24,121
	Architectural											

Area Number	DESCRIPTION	QUANTITY	UN	MANHOURS MHR/ UNIT	TOTAL MH	MATERIAL UNIT COST	TOTAL MATL	LABOR WAGE RATE	TOTAL LABOR	EQUIPMENT UNIT RATE	TOTAL EQUIP	TOTAL DIRECT COST
	Exterior											
	12" CMU w/4" Brick Façade w/Insulation (truck Bay/Admin)	3,660	SF	0.37	1,354	10.00	36,600	$81.21	109,976	0.00	0	$146,576
	Roof											
	Shingle Roof (truckBay/Admin)	34	SQ	14.40	484	1,008.00	33,869	$81.21	39,293	72.00	2,419	$75,581
	Insulation (2")	3,360	SF	0.0060	20	0.82	2,755	$81.21	1,637	0.00	0	$4,392
	MBR Effleunt End Building (17' x 20')	340	SF	0.90	306	100.00	34,000	$81.21	24,851	2.00	680	$59,531
	Garage (24' x 24')	576	SF	0.70	403	85.00	48,960	$81.21	32,744	2.00	1,152	$82,856
	Stand Alone Tank (Eff PS)											
	Checkered Plate Cover	900.0	LBs	0.015	14	0.90	810	$81.21	1,096	0.05	45	$1,951
	Equipment											
	Headworks											
	Preliminary Screening - 2 mm	2	EA	140	280	115,000	230,000	$81.21	22,739	1,150.00	2,300	$255,039
	Coarse Bubble Diffusers (EQ Tank, WAS Tank, and TWAS Tank)	1	LS	50	50	34,000	34,000	$81.21	4,061	340.00	340	$38,401
	Equalization Tank Pumps	3.0	EA	8	24	5,500	16,500	$81.21	1,949	55.00	165	$18,614
	Guide Rail Assemblies for future pumps	2.0	EA	8	16	700	1,400	$81.21	1,299	7.00	14	$2,713
	MBR	1.0	LS	1,200	1,200	940,000	940,000	$81.21	97,453	9,400.00	9,400	$1,046,853
	Includes: membranes and cassettes, permeate pumps, scour blowers, aeration blowers,fine bubble aration discs, submersible mixers, chlorine metering pump, chemical dosing system, PLC, VFDs											
	Effluent Discharge Pumps	3.0	EA	16	48	13,500	40,500	$81.21	3,898	135.00	405	$44,803
	Guide Rail Assemblies for future pumps	2.0	EA	16	32	800	1,600	$81.21	2,599	0.00	0	$4,199
	UV (in-pipe)	1.0	EA	200	200	156,000	156,000	$81.21	16,242	1,560.00	1,560	$173,802
	Admin Building											
	Blowers - 250 scfm	4.0	EA	20	81	16,545	66,180	$81.21	6,618	160.00	640	$73,438
	Blowers - 650 scfm	2.0	EA	30	60	23,700	47,400	$81.21	4,873	250.00	500	$52,773
	Septage Receiving	1.0	EA	600	600	405,000	405,000	$81.21	48,727	6,000.00	6,000	$459,727
	Sludge Thickening - Disk Thickener	1.0	EA	225	225	181,000	181,000	$81.21	18,272	1,810.00	1,810	$201,082
	RDT Feed Pump	2.0	EA	18	36	15,000	30,000	$81.21	2,924	150.00	300	$33,224
	Load out Station	1.0	EA	18	18	15,000	15,000	$81.21	1,462	150.00	150	$16,612
	Thickened Sludge Load Out Pump	2.0	EA	30	60	25,000	50,000	$81.21	4,873	250.00	500	$55,373
	Plant Water System											
	Plant Water/Distribution Pumps (400 gpm @322', 50 hp)	2	EA	32.00	64	21,500.00	43,000	$81.21	5,197	215.00	430	$48,627
	Controller/Piping	1	AL	120.00	120	20,000.00	20,000	$81.21	9,745	200.00	200	$29,945
	Odor Control (air from septage receiving garage, headworks building, sludge storage tanks, and EQ tank)	1.0	EA	380	380	206,000	206,000	$81.21	30,860	2,060.00	2,060	$238,920
	Lab Equipment/Cabinet Allowance	1	AL	450.00	450	60,000.00	60,000	$81.21	36,545	1,000.00	1,000	$97,545
	Piping											
	Percentage of Mechanical	15%	%	3,494	524	2,483,580	372,537	$81.21	42,569	26,774	4,016	$419,122
	Electrical											
	Percentage of Project	20%	%	26,466	5,293	3,548,749	709,750	$81.21	429,872	53,278	10,656	$1,150,277
	Diesel Generator w/Acoustical Enclosure (250 KW)	1	AL	125.00	125	100,000.00	100,000	$81.21	10,151	1,000.00	1,000	$111,151
	I&C											
	50% of Electrical	50%	%	5,293	2,647	709,750	354,875	$81.21	214,936	10,656	5,328	$575,139

Area Number	DESCRIPTION	QUANTITY	UN	MANHOURS MHR/ UNIT	TOTAL MH	MATERIAL UNIT COST	TOTAL MATL	LABOR WAGE RATE	TOTAL LABOR	EQUIPMENT UNIT RATE	TOTAL EQUIP	TOTAL DIRECT COST
							Subtotal					$7,851,300
							22% Contractor, GC, Overhead and Profit					$ 1,727,286
							30% Contingency					$ 2,873,576
							5% Owner's Contingency					$ 622,608
							SUBTOTAL					$13,074,770
ESCALATION TO MID-POINT OF CONSTRUCTION		3.5%						2.62	**9.2%**			$ 1,200,461
ASSUMED AT:	**December 31, 2019**	PER YEAR						YEARS	NON-COMPOUNDED RATE			$ 14,275,231

CALCULATION REVIEW CHECKLIST

PROJECT:	WWTP Improvements	**Job No.:**	60476644.10.1.C		
CLIENT:	Orleans, MA	**Discipline:**	Estimating	**Calc No.:** **Rev No.:**	
SUBJECT/TITLE:	WWTF - SBR vs MBR	**TTP NO. (if used):**			
ORIGINATOR	R Mastrogiacomo	**DISCIPLINE REVIEWER**			
TECHNICAL DISCIPLINE LEAD	J. Reade	**INDEPENDENT CALCULATION PREPARER (if used)**			

Discipline Review

	YES	NO	N/A
1. Is the calculation in accordance with a standard approach to preparing the design?			
2. Have input data and information been verified and accepted?			
3. Have assumptions requiring follow-up been reviewed and confirmed?			
4. Are the mathematics correct?			
5. Are results and conclusions consistent and reasonable considering the inputs and approach?			
6. Have the originator and the checker/reviewer signed and dated the calculation?			
7. Have all previous internal review comments been addressed and closed out with the originator?			
8. Have all previous client review comments been addressed and closed out?			

Explain "No" responses:

Discipline Reviewer: ____
Signature/Date

Independent Calculations (in lieu of Discipline Review)

A separate, independent set of calculations has been prepared, validating the original calculations.

Independent Calculation Preparer ____
Signature/Date

Independent Peer Review (if required in Project Plan or as determined subsequently to be necessary)

All comments, issues and concerns of this special Independent Peer Review have been addressed and closed out.

Independent Peer Reviewer ____
Signature/Date

Technical Discipline Lead Concurrence

The originator, discipline reviewer (or independent calculation preparer), and independent peer reviewer (if required) are appropriately qualified for the development of this calculation; a proper review has been completed; and all review comments have been addressed and

Technical Discipline Lead ____
Signature/Date

Q3NA-351-FM1