

ADDENDUM

Perdue Water Treatment Plant SITE FACILITIES MASTER PLAN UPDATE

July 2024



Sweetwater Authority

1 Introduction

Sweetwater Authority (Authority) has prepared this addendum to the Site Facilities Master Plan Update for the Robert A. Perdue Water Treatment Plant(Perdue Master Plan) to incorporate the proposed Sweetwater Reservoir aeration and destratification system (Aeration System) into the Perdue Master Plan. The Aeration System was not explicitly referenced in the Perdue Master Plan because the Authority was already pursuing design and implementation of it. However, there exists a nexus between the Aeration System and the Perdue Master Plan based on the following attributes of the proposed Aeration System:

- its compressors, controls, and power components are based on the Perdue Treatment Plant site;
- the Aeration System pipes are in the portion of the reservoir nearest the Perdue Treatment Plant; and
- it serves a pre-treatment function for the Perdue Treatment Plant by enhancing water quality in the Sweetwater Reservoir, particularly in the vicinity of the Perdue Treatment Plant's intake tower at the reservoir.

Therefore, although the Aeration System was not explicitly referenced in the Perdue Master Plan, it is associated with the Perdue Treatment Plant and the scope of the Perdue Master Plan, and is thus incorporated into the Perdue Master Plan via this addendum.

2 Aeration System

The engineering and conceptual design for the Aeration System were performed by Hazen and Sawyer and documented in a Preliminary Design Technical Memorandum (Hazen and Sawyer, 2022) that is attached hereto and incorporated into the Perdue Master Plan by reference.

A new Aeration System was initially recommended in the Feasibility Study to Maximize Reservoir Assets and Expand Local Water Supply (Gillingham Water Planning and Engineering, 2020), which indicated that an Aeration System in Sweetwater Reservoir would improve water quality in the water resource that the reservoir provides and thereby increase the yield of treatable water from the reservoir, thus reducing dependence on higher-cost imported water supply. Hazen and Sawyer proposed a linear diffused air system whereby diffused air bubbles facilitate mixing of the temperature-stratified water column in the reservoir, fostering homogenized water temperature and quality in the water column while assisting with suppression of nutrient-laden sediment to the reservoir bottom. The intended outcome is the reduced frequency of algae blooms as well as more uniform and favorable water quality of Perdue Treatment Plant influent that will result in a decreased chemical usage (cost savings). Additionally, overall lake ecosystem benefits will result from operations of the proposed Aeration System.

APPENDIX

Preliminary Design Technical Memorandum for the Sweetwater Reservoir Aeration/Destratification System

Hazen *Technical Memorandum*

November 18, 2022

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Re: **FINAL Preliminary Design Technical Memorandum**
Sweetwater Reservoir Aeration/Destratification System
Sweetwater Authority Project No. **BP 20228002**
Hazen Project No. **20178-002**

Sweetwater Reservoir Aeration/Destratification System

FINAL Preliminary Design Technical Memorandum

Introduction

The Sweetwater Authority (Authority) is interested in reducing dependency on costly imported water supplies, and in 2020, completed a Feasibility Study to Maximize Reservoir Assets and Expand the Local Water Supply. The Feasibility Study recommended implementation of an aeration/destratification system in Sweetwater Reservoir to improve water quality and thereby increase the yield of treatable water from the reservoir. Hazen and Sawyer (Hazen) has been retained by the Authority to design the aeration/destratification system.

This technical memorandum summarizes the preliminary design of the aeration system for destratification of the Sweetwater Reservoir, including design criteria and preliminary design schematics. Hazen is performing preliminary design of the on-shore components of the system, which are described in this document, and Water Quality Solutions (WQS) is providing preliminary design for the underwater components, as described in their draft technical memorandum in **Appendix A**, referenced throughout this document.

Two alternative locations for the on-shore components and two alternative diffuser lengths are evaluated in this document, for a total of four alternatives. Upon receipt of Authority comments and conducting the draft TM review meeting, this draft document will be revised and reissued as a final document.

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1. Existing Conditions

Hazen reviewed available record drawings and documents provided by the Authority to develop the basis of existing conditions in the Sweetwater Reservoir and the Robert A. Perdue Water Treatment Plant site. Authority staff have also been an important source of information.

1.1 Sweetwater Reservoir

The Sweetwater Reservoir located in Spring Valley, CA, has a storage capacity of 28,079 acre-feet (AF) and serves as a local surface water source for the Sweetwater Authority's drinking water supply. Formed in 1977 as a joint powers agency, the Sweetwater Authority (Authority) owns and operates two surface water reservoirs, Sweetwater Reservoir and Loveland Reservoir, and serves potable water to a population of approximately 200,000 in a 36-square-mile service area including the City of National City, the western portion of the City of Chula Vista, and the unincorporated areas of Bonita and Lincoln Acres, in San Diego County, CA. Both reservoirs are located in the Sweetwater River Watershed, with Loveland Reservoir located approximately 17 miles upstream of Sweetwater Reservoir, near Alpine, CA.

Surface water from Sweetwater Reservoir is treated at the adjacent Robert A. Perdue Water Treatment Plant (Perdue WTP) located in Spring Valley, CA, which has the capacity to produce a maximum of 30 million gallons per day (MGD). Loveland Reservoir is not directly connected to the Authority's water treatment and distribution system. Therefore, to use water in Loveland Reservoir, water is released from Loveland Dam and travels downstream through the Sweetwater River into Sweetwater Reservoir, where it can then be pumped into the Perdue WTP for treatment. The Authority usually releases water from Loveland Reservoir during the wettest months of December through March when river and environmental conditions are ideal to minimize water losses during the planned water transfer. During years when the Authority does not complete a water transfer from Loveland Reservoir to Sweetwater Reservoir due to drier conditions in Sweetwater River or insufficient water storage in Loveland Reservoir, the Authority's dependence on purchased imported water from the San Diego County Water Authority (SDCWA) increases.

Since 1955, local surface water and groundwater sources have met approximately 45 percent of the water demands in the Authority's service area, while the 55 percent balance has been met with imported water supplies. During wet years when there is sufficient water storage in Sweetwater and Loveland Reservoirs, the Authority can sometimes rely on 100 percent local water supplies.

1.2 Robert A. Perdue Water Treatment Plant Site

Compressor equipment for the aeration system is to be located on the Perdue WTP site, located at 100 Lakeview Avenue, Spring Valley, CA, adjacent to Sweetwater Reservoir and Sweetwater Dam. Housing the compressors in the existing PAC building was evaluated, as described later in this report, but ultimately the equipment requires a larger footprint so two alternative locations were evaluated. These locations and other adjacent facilities are shown in **Figure 1-1**.

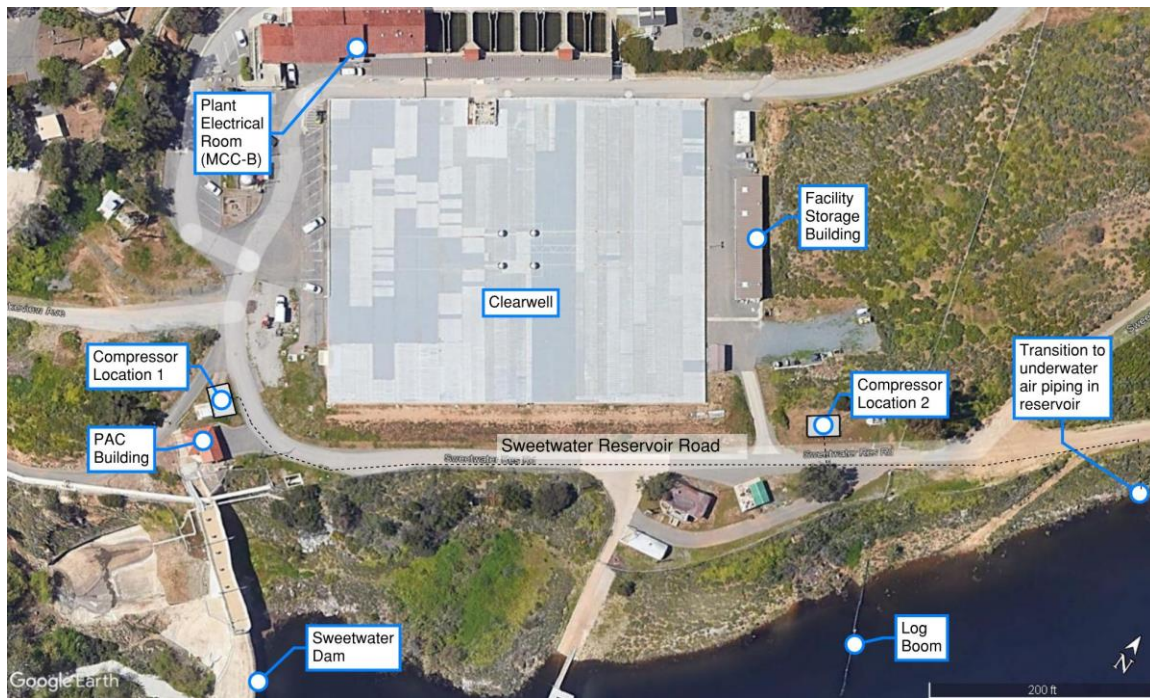


Figure 1-1: Site overview at Perdue Water Treatment Plant

1.3 Reservoir Water Quality Summary

Sweetwater Reservoir, like many other reservoirs, is a eutrophic, dynamic ecosystem with annual and seasonal variations in water levels, inflows, nutrient loading, temperatures, and dissolved oxygen levels. Though thermally stratified most of the year, it experiences an annual turn-over event, during which dissolved metals such as iron and manganese are released from the sediment into the anaerobic lower reaches of the reservoir. Water quality issues like these affect the Authority's ability to treat the water at the adjacent Perdue WTP, and lead to increased turbidity and discoloration in the distribution system from higher levels of iron and manganese, resulting in increased treatment costs and increased reliance on more expensive imported water sources. Destratification aims to increase dissolved oxygen and improve the treatability of the reservoir water, reducing reliance on imported water.

Improving water quality by preventing anoxic conditions may have the unfortunate side effect of aiding the proliferation of an invasive species, quagga mussels, in the reservoir. Quagga mussels are currently controlled by the reservoir's thermal stratification, as well as other control strategies. To compensate, it may be necessary for the Authority to implement additional quagga mussel control strategies in addition to the those already being implemented. Coordination with regulatory agencies including the California Department of Fish and Wildlife and the Regional Water Quality Control Board, as well as updates to the Authority's quagga mussel control plan are included as a separate task in this project.

1.4 Reservoir Subsurface Conditions and WSEL Fluctuations

Background review and subsurface exploration indicated that the Sweetwater Reservoir is generally underlain by alluvium, terrace deposits, Mission Valley Formation, and metamorphic rock. The October 2020 Ninyo & Moore Geotechnical Data Report entitled Sweetwater Reservoir Sediment Study, summarizes the results of geotechnical and analytical laboratory analysis of sediment samples from 12 locations in the reservoir. Boring locations closest to the proposed diffuser layout for this project indicate that the sediment depth to refusal is approximately 22.5 to 43.5 feet, with deepest sediment near the outlet tower.

Authority staff have indicated that they are considering dredging in the reservoir in the future, in part due to the accumulation of sediment near the outlet tower. While Hazen and WQS have considered placement of the diffuser to avoid some of the likely impacts of dredging near the outlet tower, it is outside the scope of this project to design the aeration system to accommodate future dredging because details of this potential project are not available. The location of our proposed diffuser lines avoids the immediate area around the outlet tower and the log boom. If the Authority chooses to dredge the Reservoir in the future, the diffuser assembly piping would need to be taken out of service, floated out of the way of the dredging equipment and re-installed once dredging is complete. The piping would need to be protected from the sun while out of service and the pressure requirements and anchoring of the system should be re-evaluated if the reservoir depths change significantly.

The Sweetwater Reservoir has a maximum storage capacity of 28,079 acre-feet (AF) that corresponds to a maximum water surface elevation (WSEL) of 239 feet. In the period from 2002 to 2020, the storage in the Reservoir varied from 2,800 to 23,200 AF. The operating pool of the reservoir goes down to an elevation of 196.6 and below that the Authority has an emergency storage between 189 feet and 196.6 feet. The system will be designed to aerate between the dead pool and maximum storage levels. However, it is designed to be most effective between 3,350 and 20,000 AF.

2. Regulatory Considerations

The Authority complies with all Federal and State water quality regulations. The reservoir improvements are a result of a program to better mitigate secondary contaminants such as iron, manganese and taste and odor.

2.1 Required Regulatory Reviews and Approvals

The project will require coordination with the State Water Resources Control Board (SWRCB), Division of Drinking Water (DDW) because the Authority will need to apply for an amendment to the Authority's drinking water permit. The completed Preliminary Design Report will be submitted to DDW for their review and to initiate discussions.

Environmental documentation and permitting is being performed by the Authority under a separate contract.

3. Basis of Design

This section reviews the objectives and typical features of aeration/destratification systems, discusses considerations for future modification of the system, describes the components and design criteria, proposes alternative locations for the on-shore equipment, presents the electrical evaluation, instrumentation and controls, and describes typical operations and maintenance requirements.

3.1 Reservoir Aeration/Destratification System Objectives

In the previous study by Gillingham Water and WQS (Gillingham Water, 2020), several alternatives for water quality improvement in Sweetwater Reservoir were evaluated: hypolimnetic oxygenation (Speece Cone, SDOX, and diffused oxygenation), destratification by aeration, and vigorous mixing. On the basis of the cost/benefit analysis, the Authority selected destratification by aeration as the preferred alternative in year 2021.

A destratification system destratifies a reservoir through entraining water with an upward stream of air bubbles. It brings deep, anoxic water to the surface that is replaced by downwelling of oxygenated surface water. This leads to oxygenated water with uniform water quality throughout the reservoir, which decreases hydrogen sulfide (H₂S) and manganese levels and decreases internal nutrient cycling.

Destratification can be achieved in Sweetwater Reservoir with a single line diffuser near the deepest part of the reservoir. The proposed system will effectively destratify Sweetwater Reservoir at historical storage volumes observed from 2002 to 2020, with additional benefits expected at low storage volumes below 10,000 acre-feet, as described in WQS's preliminary design report, in **Appendix A**.

3.1.1 Diffused Aeration System

A diffused aeration system with a linear diffuser consists of a series of porous bubble tubes which are suspended just above the reservoir bottom, as shown in **Figure 3-1**. The system is supplied with a constant stream of air from compressors on-shore and is designed to facilitate complete mixing of the reservoir system. As the hypolimnion is brought to the surface, it mixes with the warmer epilimnion. Over time, this results in a constant temperature gradient with depth and prevents thermal stratification of the reservoir. The deeper water is exposed to atmospheric oxygen through the mixing action, which prevents anoxic conditions and reduces soluble metals.

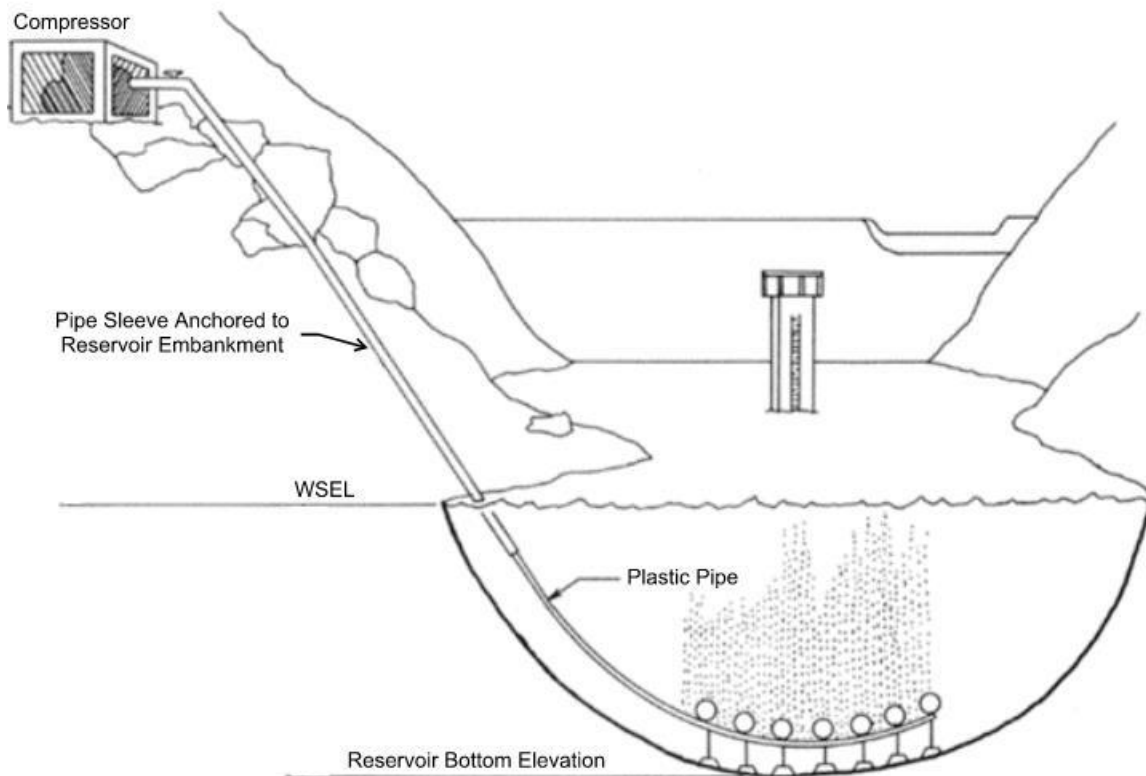


Figure 3-1: Typical diffused aeration system with linear diffuser (WQS Figure 3.1)

Diffused air systems are relatively low maintenance, and do not require special knowledge to operate once they are installed. Proper design of a diffused aeration system is critical. If the aeration system is undersized, the mixing action will only serve to blend the epilimnion and hypolimnion, reducing overall dissolved oxygen levels in the reservoir. It should also be noted that complete mixing can bring nutrients from the bottom sediments into the water column. This typically does not affect a reservoir mixed with a properly designed diffused air system, because the water column is turned over before algae can develop at the surface. However, if mixing velocities are too low, algal blooms can develop rapidly.

3.1.2 Future System Modifications (Hypolimnetic Oxygen System)

The Authority requested that the system be designed to allow future modifications, such as conversion to a hypolimnetic oxygen system (HOS). Hazen and WQS have identified several considerations that influence whether the system can later be modified for diffused oxygenation, both for the piping system and on-shore equipment. One is that the longer diffuser length option of 2,000 feet would need to be selected. The air supply piping must be free of oil and other contaminants to be re-used for a system that supplies oxygen. Regardless of whether the system will be modified in the future for use with oxygen, our design will specify either an oil free compressor or an oil-flooded compressor (using food-grade oil) with an oil separator and air dryer to keep oil out of the piping and the reservoir. Finally, the on-shore equipment for an oxygenation system would require additional footprint compared to the aeration system and exact size requirements depend on the type of future system selected. For example, a liquid

oxygenation system would require a horizontal or vertical oxygen tank of roughly 10 feet in diameter by 30 feet, mounted to a concrete pad. It also requires two vaporizers that are slightly smaller than the tank and does not require compressors. An example of a similar-sized system at Lake Casitas is shown in **Figure 3-2**. While sizing of the oxygen system is outside the scope of this project, it is recommended that a location be identified with spare footprint for future on-shore modifications and that is accessible for liquid oxygen deliveries.



Figure 3-2: Example horizontal liquid oxygen tank, vaporizers, and delivery truck (Lake Casitas, Mobley Engineering)

3.2 Aeration System Components and Design Criteria

The aeration/destratification system includes several on-land and under-water components. See **Figure 3-3** for the overall layout of air piping on site, in which two alternatives for the line diffuser are shown. On land, two air compressors operated together in series, will generate compressed air, which will be stored in an air receiver tank. Air will be released at a constant pressure from the air receiver tank through a buried air supply pipeline to the edge of the reservoir, where it will be secured to the banks of the reservoir down to the deadpool water storage level and attached to a buoyancy pipe, as shown in **Figure 3-4**.

Within the reservoir, the 3-inch air supply pipeline and 4-inch buoyancy pipe run underwater to the start of the single line diffuser, just east of the log boom. This location for the beginning of the diffuser was chosen because it corresponds to the deepest, flattest area of the reservoir that also avoids the sediments near the outlet tower and does not require removal of the log boom during installation or maintenance. The line diffuser extends out into the reservoir either 500 feet (Alternative A shown in green) or 2,000 feet (Alternative B shown in purple), as further detailed in WQS's PDR (**Appendix A**).

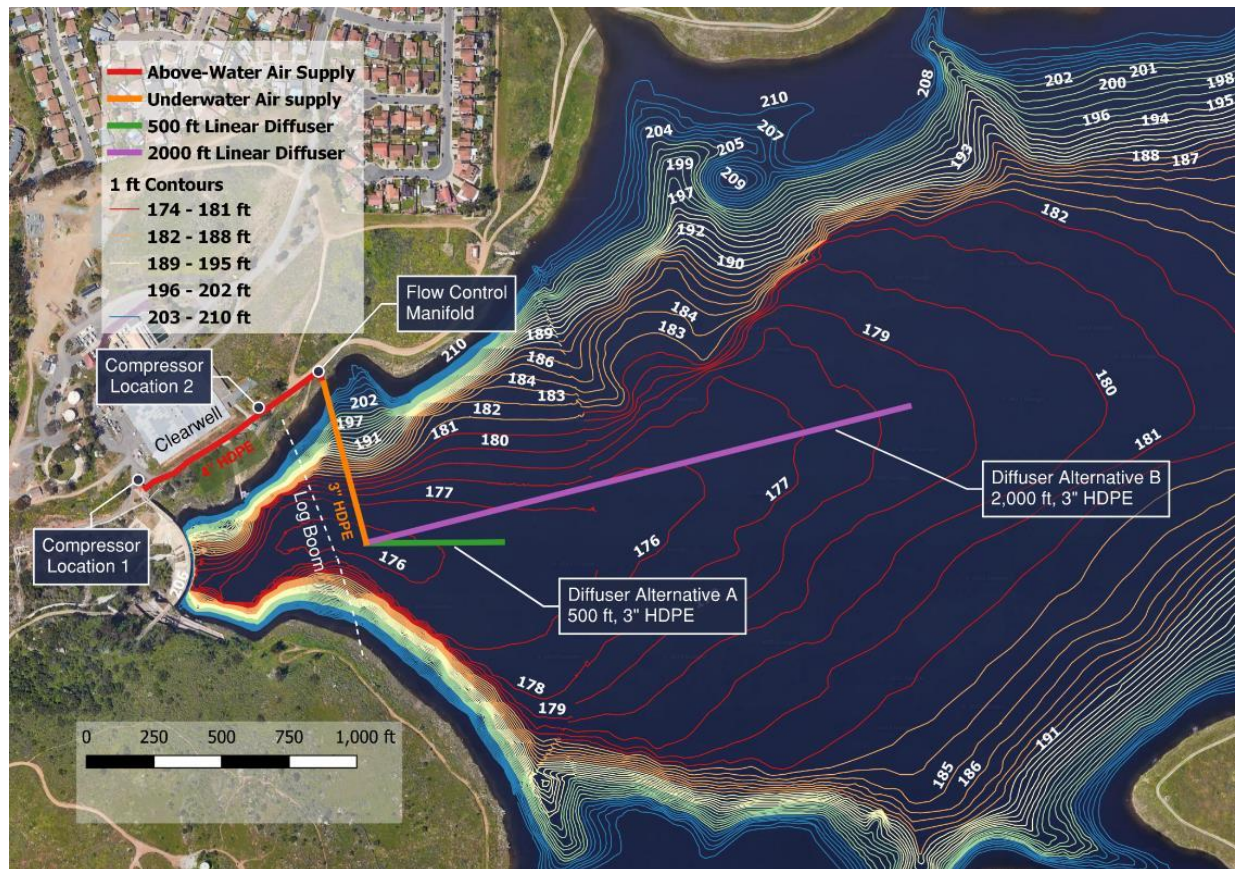


Figure 3-3: Air piping layout with alternative compressor locations and diffuser lengths

3.2.1 Air Compressors

WQS has documented the details of the air flow calculations in **Appendix A**, which Hazen has used to specify the compressors. The diffuser system requires a total air flow of 680 scfm, which will be provided with two equally sized 75 horsepower (hp) rotary screw air compressors. The supply pressures required at the compressor outlet for a 500-foot and the alternative 2,000-foot diffuser systems at maximum WSEL are 60 psi and 69 psi, respectively, as shown in **Table 3-1** and **Table 3-2**. These outlet pressures are required to deliver the required pressure throughout the length of the diffuser assembly. Hazen will specify compressors capable of delivering these outlet pressures, regulated at the outlet of the air receiver tank.

Table 3-1: Calculated air flow requirement for 500-ft linear diffuser

Reservoir Storage ³ (a-f)	WSEL (ft)	Supply Pressure (psia)			Flow Difference ¹	Total Air Compressor Horsepower Needed ²
		Compressor Outlet	Beginning of underwater supply pipe	Beginning of Diffuser		
3,350	196.6	53	51	44	±3%	79
28,079	239	60	57	51	±4%	87

1. Flow difference defined as $\text{Max}[|Q_{\text{max}} - Q_{\text{mean}}|, |Q_{\text{min}} - Q_{\text{mean}}|]/Q_{\text{mean}} \times 100\%$
2. One-stage of compression and 85% compressor efficiency are assumed
3. Diffusers will be at elevations of 179 to 189 feet, which is below the dead pool elevation of 189 feet.

Table 3-2: Calculated air flow requirement for 2,000-ft linear diffuser

Reservoir Storage ³ (a-f)	WSEL (ft)	Supply Pressure (psia)			Flow Difference ¹	Total Air Compressor Horsepower Needed ²
		Compressor Outlet	Beginning of underwater supply pipe	Beginning of Diffuser		
3,350	196.6	67	64	59	±7%	96
28,079	239	69	67	61	±9%	99

1. Flow difference defined as $\text{Max}[|Q_{\text{max}} - Q_{\text{mean}}|, |Q_{\text{min}} - Q_{\text{mean}}|]/Q_{\text{mean}} \times 100\%$
2. One-stage of compression and 85% compressor efficiency are assumed
3. Diffusers will be at elevations of 179 to 189 feet, which is below the dead pool elevation of 189 feet.

The dead pool and emergency storage volume is between WSEL 189 and 196.6 feet. The aeration system diffusers are located between elevations 179 to 182 feet. The aeration system operates to aerate any water above the diffuser level. However, at lower elevations, the aeration system may operate with decreased efficiency. If this occurs, the Authority should monitor system performance, water quality, and temperature profiles in Sweetwater Reservoir to determine the optimal operation of the system to provide aeration that will assist treatability at Perdue. At high storage (above 20,000 AF), the system would continue to aerate the reservoir, but weak stratification may develop in the warmer months, and turnover time would be extended.

An air compressor system must discharge oil-free air to the diffuser supply piping. The use of oil-free compressors is an option if the Authority wants to modify the system for HOS. However, it should be noted that oil free compressors are significantly more expensive than conventional oil-flooded compressors which have been used for other similar reservoir aeration projects. Therefore, conventional rotary screw compressors capable of operating with food-grade oil will be specified. Each will be fitted with an oil coalescing filter to prevent oil from passing to the air piping or reservoir. Details of the proposed compressor equipment and optional oil free compressor system are included in **Appendix B**.

Full redundancy (capacity plus one spare) is not required. However, the installation of two half-size compressors will allow the Authority the flexibility to continue to aerate the reservoir at half of the air flow rate, which WQS modeling results show still provides some benefit, should one of the compressors require maintenance. In addition, the two smaller units allow the Authority to shut down half of the connected horsepower operating if water quality improves to a point where both are not necessary. This determination would be made empirically based on water quality, reservoir volume, and strength of

stratification. If one compressor was turned off during the summer or at higher reservoir volume, stratification may develop. The Authority would need to monitor system performance and temperature profiles in Sweetwater Reservoir to determine the optimal operation of the aeration system and perform maintenance on the compressors during times of weakest stratification. The compressors will be constant speed units. The compressors will be specified to include a refrigerated air dryer, oil coalescing filter, compressed air filters, and air receiver tank. Compressor design criteria is summarized below in **Table 3-3**.

Table 3-3: Compressor Design Criteria

Air Compressor:	
No. of Units	2
Compressor type	Rotary screw, food grade oil
Minimum Required Supply Pressure (psia)	53
Maximum Required Supply Pressure (psia)	69
Air Flow Required, each unit (scfm)	340
Horsepower, each unit (hp)	75
Nominal Power, each unit (kW)	55
Basis of Design	Ingersoll Rand RS55I-A125, 460V, Poro, HD Inlet, Modulation w/Helix
Refrigerated Air Dryer:	
No. of Units	1
Capacity (cfm)	800
Nominal Power (kW)	6.7
Basis of Design	Ingersoll Rand NVC 800 460-3-60 Air Cooled NEMA 4 with Timed Solenoid Drain
Oil Water Separator Filter:	
Capacity (cfm)	850
Basis of Design	Ingersoll Rand PolySep AS85 Oil Water Separator
Air Receiver Tank:	
No. of Units	1
Design Pressure (psig)	150
Minimum Nominal Volume (gal)	1060
Basis of Design	Ingersoll Rand Receiver Horz 1060
Alternate System Manufacturers	Gardner-Denver Atlas Copco Quincy Compressor

3.2.2 Air Receiver Tank

The purpose of an air receiver tank is to ensure enough system volume is present to limit the number of loading/unloading cycles, and prolong the life of compressor components. The operating pressure in the air receiver varies between the set upper and lower limits, with a regulator supplying the distribution system with the constant pressure needed to supply the air diffuser. Preliminary minimum sizing for the air receiver tank is as recommended by the compressor manufacturer and will be verified by Hazen during detailed design.

3.2.3 On-Shore Compressed Air Supply Main

The compressed air piping from the air receiver tank to the reservoir will be 4" HDPE, with length of approximately 325 feet (from Location 2) or approximately 820 feet (from Location 1), depending on the location chosen for the compressors, as discussed in **Section 3.3**. The air supply piping will be buried in a trench until it reaches the top elevation of the reservoir embankment. The air supply piping will then transition above ground to a pad-mounted flow control manifold, including supply and diffuser pressure gauges, valves, and a hose fitting for a portable air compressor at the beginning of the buoyancy pipe. From the pad, the air supply and buoyancy piping will be anchored in a pipe sleeve along the embankment of the reservoir down to the deadpool WSEL of 189 feet. An example from a similar project at Lake Casitas shows how the piping is typically secured along the face of the reservoir embankment, in **Figure 3-4**.

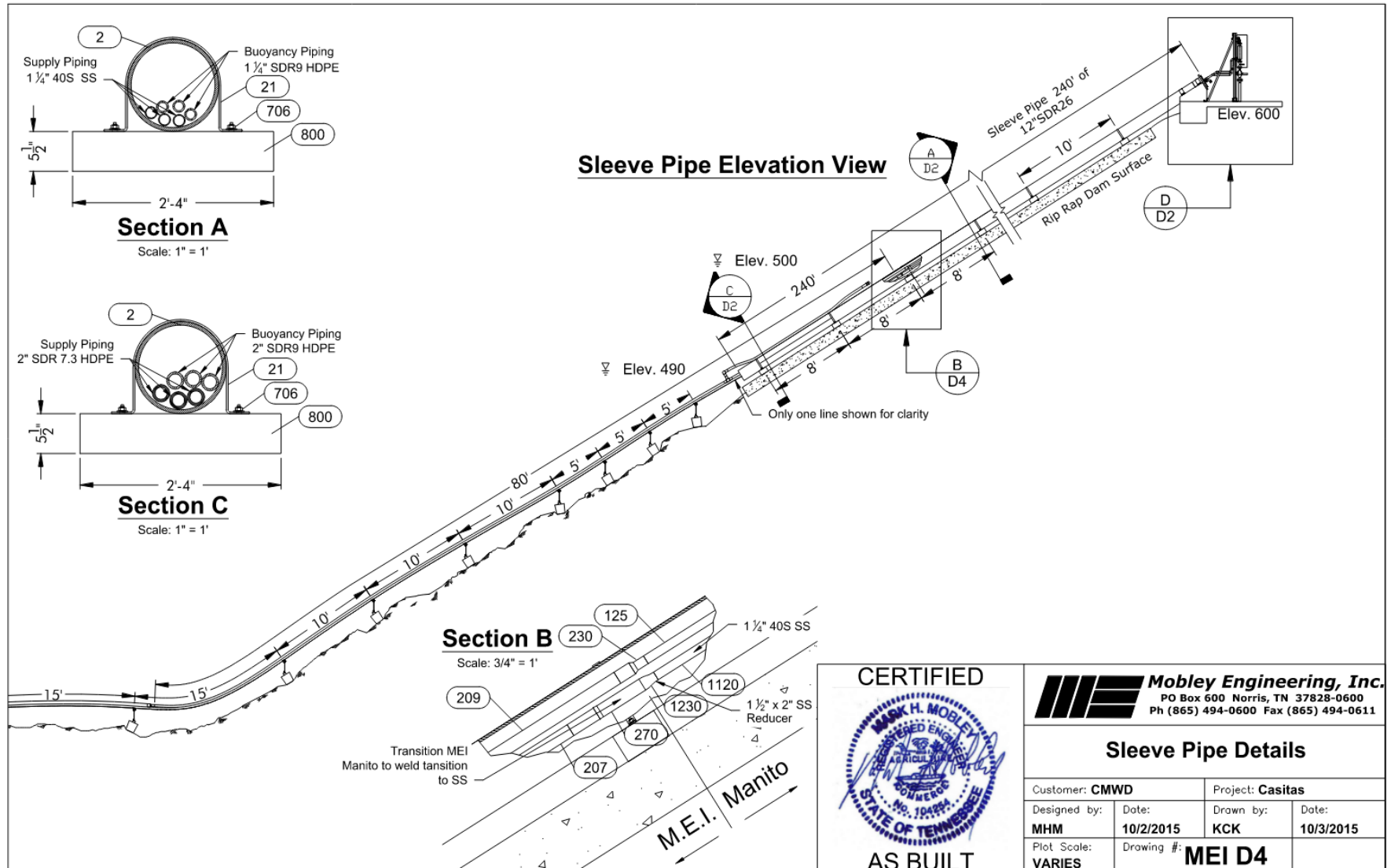


Figure 3-4: Typical air supply and buoyancy pipes transition to in-reservoir piping (Mobley Engineering)

3.2.4 In-Reservoir Air Supply Piping and Bubble Tube Line Diffuser

The in-reservoir components of the diffuser assembly consist of a 3" HDPE air supply pipe, a 4" HDPE buoyancy pipe, and porous flexible diffuser hose tubing all fastened together to generate a bubble curtain, as shown in **Figure 3-5**. The diffuser assembly is attached to concrete anchors with steel anchor cables approximately every 15 feet.

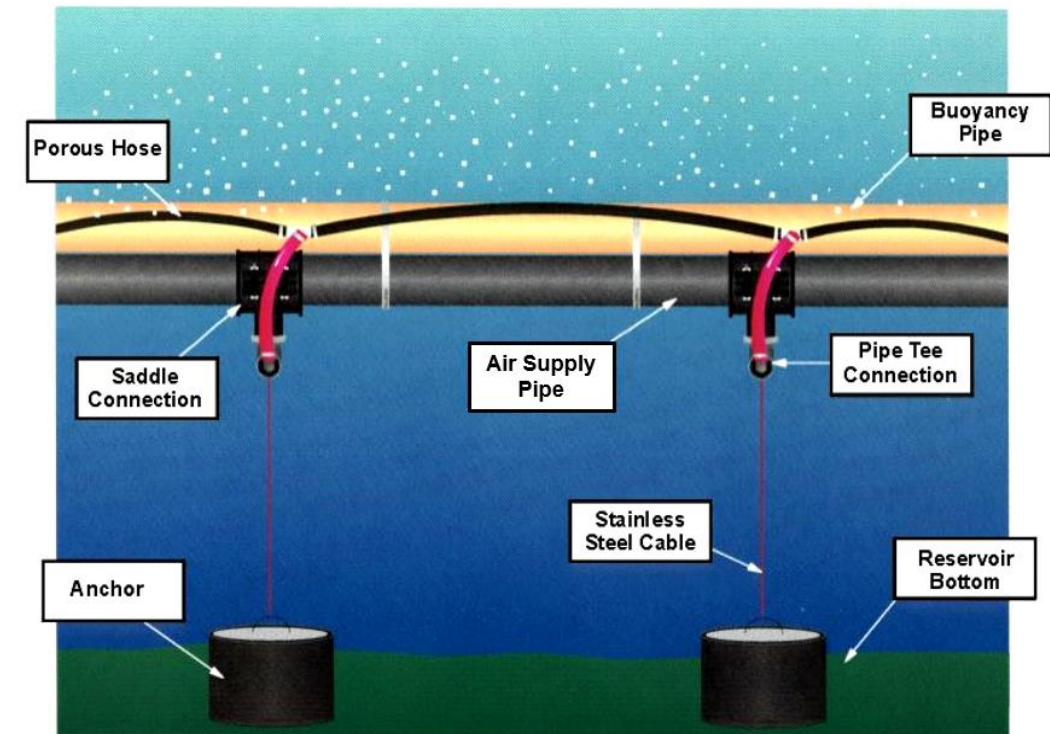


Figure 3-5: Bubble tube diffuser schematic (Mobley Engineering)

3.3 Compressor Location and Enclosure

The previous feasibility study included an assumption that the required equipment for the aeration system could be housed in the existing PAC building adjacent to the Sweetwater Dam, and Hazen started our preliminary investigations in this location. Evaluation of the PAC Building and two alternate locations are described in this section.

3.3.1 Existing PAC Building

The existing PAC building was built prior to 1959. As-built drawings of the building were not available; therefore, Hazen staff performed a site visit and developed a floor plan layout (**Figure 3-6**) using previous not-to-scale drawings supplemented by field measurements and photographs. Based on visual observation, the PAC building is a one-story building, with a footprint of approximately 30'x30' with a wood truss roof system, concrete floor, short concrete stem walls and wood walls. Concrete deterioration

was identified between concrete floor-stem wall joints which may require rehabilitation in the future. The building consists of four rooms and is currently used for housing electrical and instrumentation equipment, a compressor for an old aeration system, as well as general storage. Room 3 was part of a previous building extension according to Authority staff.

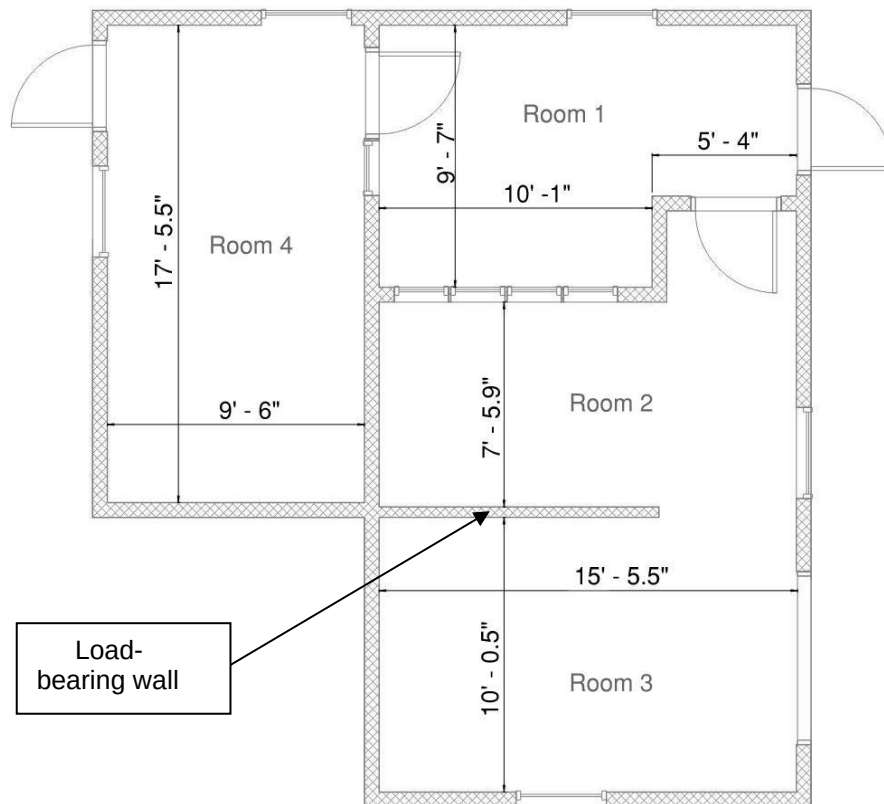


Figure 3-6: Existing PAC building floorplan

The only way to fit the compressor equipment inside the existing building allowing for minimum clearance would be to remove interior walls, including the load-bearing wall between Rooms 2 and 3. The existing concrete floor would also need to be saw cut and removed. New concrete equipment pads would be installed for anchoring purposes to support new equipment. Without existing as-built drawings, structural modifications such as new roof-penetrations, new wall-penetrations and load-bearing wall removal in the existing building would require more in-depth investigation and analysis to possibly comply with current building code requirements, which is outside the scope of this project. Even if removal of the load-bearing wall could be permitted to fit compressors inside the building, the air receiver tank and associated air dryer and air cooler equipment would require additional footprint.

Hazen concluded that the existing building is insufficient to house the new aeration system equipment and alternate locations were evaluated to place the equipment outdoors with approximately 500 square feet of space required for the compressors, air receiver tank, air dryer and associated appurtenances, to be

verified during detailed design. Two potential locations were identified for the proposed compressor enclosure, each of which is described further below.

3.3.2 Location 1 – Adjacent to Existing PAC Building

The first alternate location, Location 1 as shown in **Figure 3-7**, would require removing or relocating the existing pad-mounted storage container adjacent to the PAC Building and installing a new equipment pad and three-walled metal enclosure with a roof to protect the compressor equipment. The air receiver tank would be placed outside the enclosure on its own pad. If this location is selected, the power source for the equipment will be from MCC-B in the existing operations building, as described in **Section 3.4** – Electrical Evaluation.

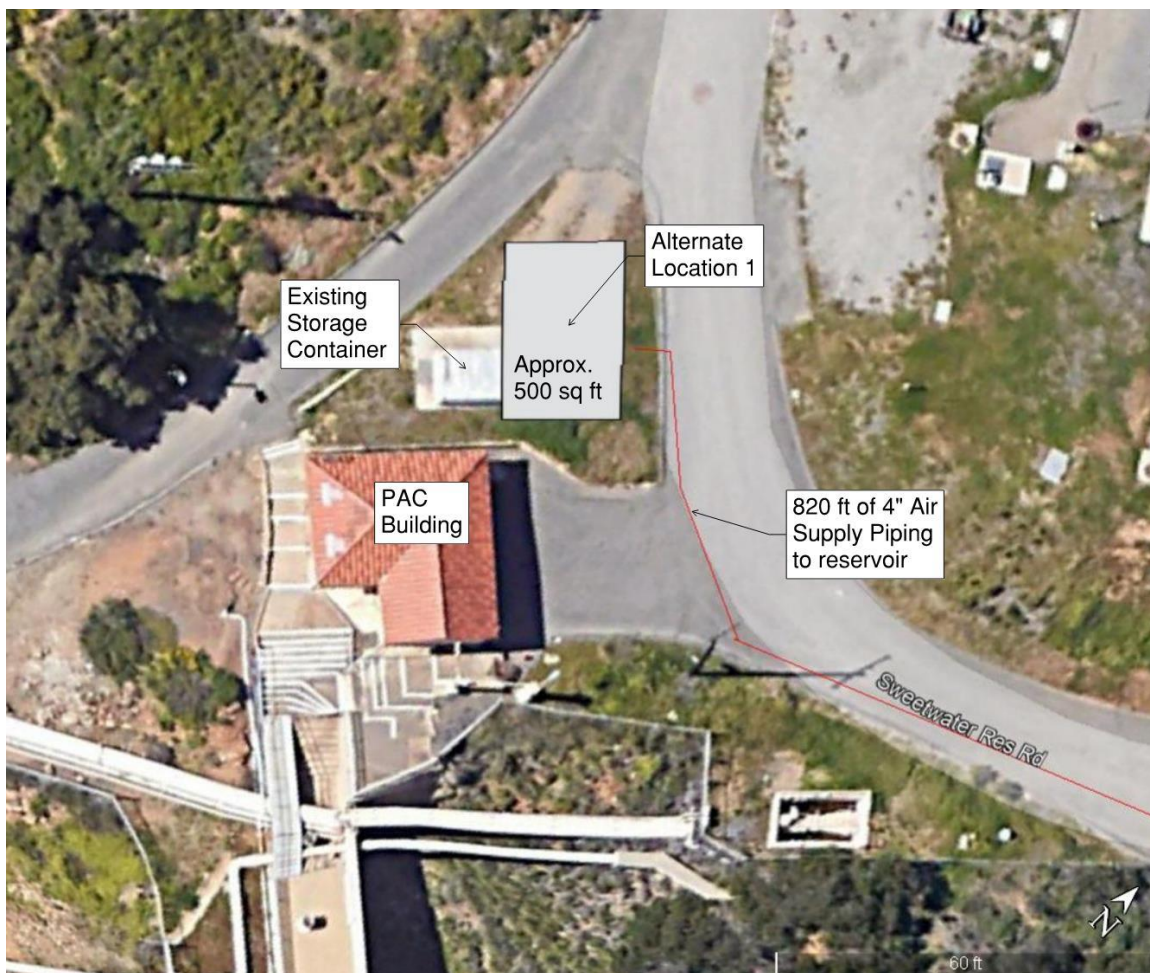


Figure 3-7: Alternate compressor Location 1 – Adjacent to PAC Building

Other than the existing storage container in this location, which would need to be relocated, there are no future facilities planned in this location according to the 2016 Site Facilities Master Plan. However, this location is in the median between two plant access roads and may create undesirable impact during construction. It also does not provide spare footprint for future expansion for an oxygenation system.

3.3.3 Location 2 – Adjacent to Road, East of Clearwell

Alternate location 2 as shown in **Figure 3-8**, is a clear, flat area on the north side of Sweetwater Reservoir Road, south of the unpaved lot. A new equipment pad and three-walled metal enclosure with a roof would be constructed to protect the compressor equipment. The air receiver tank would be placed outside the enclosure on its own pad. MCC-B (in the Operations Building) will be the power source for the equipment, as described in **Section 3.4** – Electrical Evaluation.



Figure 3-8: Alternate compressor Location 2 – south of unpaved lot along Sweetwater Res. Rd

According to the 2016 Site Facilities Master Plan, there are no future facilities planned in this immediate area shown as Location 2. Proposed Location 2 is adjacent to the proposed future residuals dewatering facilities to the north but locating the new compressors here is not expected to create any conflicts with components of the future dewatering facilities. The underground air supply piping routed from this location to the reservoir is in the vicinity of future filter wash water piping in Sweetwater Reservoir Road, but this can be avoided during design. Location 2 also provides more available footprint for future expansion for oxygenation equipment as compared to Location 1. Based on Hazen’s evaluation and discussions with Authority staff, Location 2 is preferred.

3.4 Electrical Evaluation

The Perdue WTP site is supplied by San Diego Gas and Electric (SDG&E) via 12kV overhead primary conductors. Three Unit Substations and three sets of pole mounted transformers are utilized to step the voltage down to power equipment across the facility. An overview of the three Unit Substations is shown in **Table 3-4**.

Table 3-4: Existing unit substations information

Unit Substation Tag	Electrical Information	MCC's Powered and Location of MCC
Unit Substation No. 1	Transformer: 12kV:480/277V, 1500kVA, 3Phase, 4 Wire	MCC-A (Raw Water Pump Station)
Unit Substation No. 2	Transformer: 12kV:480/277V, 1000kVA, 3Phase, 4 Wire	MCC-D (DAF Process Building)
Unit Substation No. 3	Transformer: 12kV:480/277V, 500kVA, 3Phase, 4 Wire	MCC-B (Operations Building) MCC-C (Chemical Feed Building)

Initially, Power Panel PP-PAC, located in the PAC building, was evaluated to determine if the panelboard has sufficient ampacity and spare circuit breakers to provide power to the two new air compressors to be installed as part of this project. Hazen conducted a site visit to field verify the panelboard and existing site conditions on February 25th 2022. Based on existing record drawings and information discovered during the site visit, PP-PAC is a General Electric (GE), 480/277Volt, 225Amp, 3 Phase, 4 wire panelboard. As this panelboard supplies two 45kVA transformers and one 7.5kVA transformer, the existing panelboard does not have sufficient ampacity for the two new 75hp air compressor loads, based on our calculations.

MCC-A, MCC-B, and MCC-D, representing one Motor Control Center supplied from each Unit Substation, were evaluated to help determine the most appropriate power source for the air compressors. Upon conversations with The Authority and the advantage due to proximity to either potential location, MCC-B was established as the preferred power source, and thus was evaluated in greater detail to determine if this MCC has available capacity for the new load.

In order to confirm that MCC-B is a viable power source for the new equipment, Hazen evaluated the capacity of MCC-B as well as the upstream substation (Unit Substation No. 3). The Authority provided detailed power monitoring information, extracted from an existing power monitor, for MCC-B. The Authority also installed a power monitor on MCC-C for 30-days to track operating load powered from this MCC. This information was used to calculate the existing load of MCC-B (at 125%) + the new load as approximately 427Amps. MCC-B is a 600 Amp, 480V, 3 phase, 3 wire Square D Model 6 motor control center, located in the operations building, and is sufficiently rated to handle the new load. However, the record drawings show MCC-B with a 400A main breaker. As a result, the main breaker for MCC-B will need to be replaced to accommodate the new load.

Similarly, the provided information was used to calculate the existing load of the Unit Substation No.3, MCC-B + MCC-C, (at 125%) + the new load as approximately 596 Amps, at 480V, (496kVA). As Unit Substation No. 3 is rated for 1200Amps, at 480V, with a 500kVA transformer, this substation is sufficiently rated to handle the new load. However, the record drawings show this unit substation with a 400A feeder breaker to MCC-B. As a result, this feeder breaker to MCC-B will need to be replaced to

accommodate the new load. In addition, it is anticipated the conductors and conduit between Unit Substation No. 3 and MCC-B will need to be replaced as well, and will be further evaluated during detailed design.

In addition, MCC-A and MCC-D were evaluated at a conceptual level.

- MCC-A is a 2,000 Amp, 480V, 3 phase, 3 wire switchboard/motor control center utilized for the Raw Water Pump Station. Upon performing an initial load calculation, it appears this equipment has sufficient ampacity for the two new air compressors; however, record drawings do not show sufficient space or spare breakers to accommodate the new loads. Further study would have been required to determine if MCC-A could be extended to accommodate new breakers feeding the air compressors. However, as MCC-B was identified as the preferred power source, and as having sufficient capacity, no further investigation was conducted.
- MCC-D is a 1,200 Amp, 480/277V, 3phase, 4 wire motor control center located in the DAF process building. Power monitoring information provided by The Authority shows that this MCC has capacity for the new load, however due to proximity to the proposed location of the air compressors, was not selected.

In conclusion, the new aeration equipment is planned to be powered from MCC-B (located in the operations building). Upgrades to MCC-B, the upstream substation (Unit Substation No.3), and new conduit/cable between the substation and MCC are anticipated. Based on the decision to locate the air compressors in Location 2: south of unpaved lot along Sweetwater Reservoir Road, as outlined in **Section 3.3.3**, it is anticipated to route the electrical conduits from MCC-B along the east side of the existing clearwell to the new air compressors.

3.5 Operation Strategy, Instrumentation and Controls

The planned operation strategy is that the two compressors will run continuously at full power to achieve and maintain destratification in the Reservoir. There are several factors that may influence the desired operation strategy, such as water quality, storage volume, and energy savings. The decision to turn the system on or off or to run only one compressor instead of two will be manual; made by plant operators. The system will be equipped with remote as well as local start/stop controls. WQS has recommended guidelines for system operation in **Section 5 of Appendix A** which provides more detail about the duration to destratify the reservoir at half and full power and recommended operation under various storage conditions. Because release and mixing of nutrients from the bottom sediments is possible if the system is started during times of strong stratification, it is recommended that the system be started in the winter months when Sweetwater Reservoir is de-stratified and then run continuously throughout the year, except for times when quagga control is necessary.

Initially, the PAC building was evaluated to determine if the new air compressors could be located within the existing building. IOC-3200, located within the PAC building, contains Schneider Electric input/output cards, a 24VDC power supply and UPS, multiple ethernet switches, and a Moxa media converter to communicate fiber to master PLC. Based on Hazen's site visit, it appears this remote I/O

cabinet has sufficient spare terminal blocks, I/O cards, and space to support monitoring and control of the new air compressors.

However, based on MCC-B being determined as the preferred power source for the air compressors, as described in Section 3.4 – Electrical Evaluation, Hazen intends to utilize an existing PLC or IOC panel located in, or in the vicinity of, the existing operations building. Utilizing a PLC in the same vicinity as the power source will help to reduce construction costs by utilizing the same conduit path for power and communication conduits, to the extent possible.

3.6 Operational and Maintenance Needs

3.6.1 Compressor Maintenance

Compressors and associated equipment will require periodic inspections and maintenance, as recommended by the manufacturer, to ensure proper lubrication, check for corrosion, and prevent premature deterioration or malfunctions of the equipment. Rotary screw air compressor components that require inspection and maintenance include lubricants, filters, drive train belts, and bearings.

3.6.2 Diffuser Assembly Maintenance

Inspection and maintenance of the diffusers in the reservoir is recommended approximately every 10 years, including replacement of porous tubing. It is recommended that the Authority hire a qualified contractor to raise the diffuser assembly to the surface, replace any defective portions, and ensure the diffuser piping is replaced in the correct position on the reservoir bottom. Our team has previously worked with Mobley Engineering for similar systems. Alternatively, this work can be performed by Authority staff if available.

4. Anticipated Drawing List

Drawings anticipated for the Sweetwater Reservoir Aeration/Destratification System are shown in **Table 4-1**. Any necessary plumbing work will be shown on the mechanical drawings. Heating and ventilation improvements will be described in the specification for the outdoor enclosure.

Table 4-1: Preliminary drawing list

Division	Number	Drawing	Title
General	1	G-1	Title Sheet
	2	G-2	Sheet Index and Location Map
	3	G-3	Notes, Symbols, and Legend
Civil	4	C-1	Site Plan
	5	C-2	Landward Aeration Piping Plan and Details
	6	C-3	In-Water Aeration Piping Plan
Struct	8	S-1	General Notes
	9	S-2	Equipment Pad and Enclosure
		S-3	Miscellaneous Details
Mech	10	M-1	Mechanical Plan
	11	M-2	Mechanical Sections
	12	M-3	Aeration System Details (1)
	13	M-4	Aeration System Details (2)
	14	M-5	Miscellaneous Mechanical Details
Elec	15	E-1	Legend and Symbols
	16	E-2	General Notes
	17	E-3	Electrical Site Plan and Duct Bank Schedule
	18	E-4	Partial Site Plan 1 (Unit Substation No. 3 to Ops Building)
	19	E-5	Partial Site Plan 2 (Ops Building to Air Compressors)
	20	E-6	Unit Substation No. 3 Single Line
	21	E-7	MCC-B Single Line and Elevation
	22	E-8	Control One-Line, Panel, Conduit and Wire Schedules
	23	E-9	Electrical Details
Inst	24	I-1	Symbols and Legend
	25	I-2	Network Architecture and PLC Tie-in
	26	I-3	P&ID
	27	I-4	I&C Details

5. Schedule

Based on the current design schedule, is anticipated that the completed Preliminary Design Technical Memorandum will be complete in November 2022 and the final design submittal is scheduled for June 2023.

6. Cost Estimate

The capital costs of the aeration system alternatives described herein are estimated from approximately \$1,256,000 to \$1,487,000 in 2023 dollars. This cost includes contractor overhead and profit and 30% design contingency. Cost estimates for the two alternative diffuser lengths were obtained from Mobley Engineering. The costs of four alternatives are summarized below for comparison. A detailed breakdown of the cost estimate is presented in **Appendix C**.

Alternative 1A – \$1,256,000

- Install compressor equipment pad and enclosure at Location 1, near existing PAC building
- Install approximately 820 feet of buried 4” air supply piping
- Install pad-mounted flow-control manifold at top elevation of reservoir
- Install a 500-foot diffuser system in the reservoir
- Install electrical conduit from MCC-B to Location 1

Alternative 1B– \$1,434,000

- Install compressor equipment pad and enclosure at Location 1, near existing PAC building
- Install approximately 820 feet of buried 4” air supply piping
- Install pad-mounted flow-control manifold at top elevation of reservoir
- Install a 2,000-foot diffuser system in the reservoir
- Install electrical conduit from MCC-B to Location 1

Alternative 2A– \$1,309,000

- Install compressor equipment pad and enclosure at Location 2, near the unpaved lot east of the clearwell
- Install approximately 325 feet of buried 4” air supply piping
- Install pad-mounted flow-control manifold at top elevation of reservoir
- Install a 500-foot diffuser system in the reservoir
- Install electrical conduit from MCC-B to Location 2

Alternative 2B– \$1,487,000

- Install compressor equipment pad and enclosure at Location 2, near the unpaved lot east of the clearwell
- Install approximately 325 feet of buried 4” air supply piping
- Install pad-mounted flow-control manifold at top elevation of reservoir
- Install a 2,000-foot diffuser system in the reservoir
- Install electrical conduit from MCC-B to Location 2

Assumptions:

- The lower cost oil-flooded compressor system (with oil/water separators) is selected

7. Conclusions and Recommendations

Hazen’s evaluation of alternatives and discussions with Authority staff during preliminary design have resulted in the selection of Alternative 2B, which includes a 2,000 foot long diffuser and compressors located to the southeast of the clearwell. This alternative was selected because:

- This location provides available footprint for future expansion of a hypolimnetic oxygen system.
- It requires a shorter length of air supply piping to the reservoir.
- There is less utility congestion on the east side of the clearwell for routing of electrical conduits to MCC-B.
- Conduit routing avoids the area west of the clearwell which includes planned electrical vehicle charging stations.

System summary and recommendations are as follows and will be incorporated moving forward into the final design.

- **Two 75-hp rotary screw air compressors** will be specified as described in Table 3-3 in Section 3.2.1. These compressor systems use food-grade oil and oil-water separator filters, along with associated equipment including an air dryer and air receiver tank.
- The compressors will be located on an equipment pad with a three-walled enclosure in a cleared area southeast of the clearwell, as shown in Figure 3-8.
- **Diffuser length will be 2,000 feet.** While the budgetary considerations are a necessary decision factor, Hazen and WQS recommend selecting the longer diffuser (Alternative B) if possible. Benefits of the longer 2,000-foot diffuser system include better control of cyanobacteria growth throughout the reservoir and the possibility of reusing the piping in a future modification to a hypolimnetic diffused oxygen system. Additionally, Hazen’s anecdotal experience has shown that longer diffusers aerating a larger area of a reservoir provide better mixing and water quality improvements than shorter diffusers, even though these results cannot be definitively predicted by the one-dimensional models used to evaluate aeration systems, since these models include an assumption that reservoirs are horizontally homogeneous.
- **Electrical feed will be provided from MCC-B**, located in the operations building. Conduit between MCC-B and the air compressors will be routed around the east side of the clearwell.
- **Electrical improvements** will be required as described in Section 3.4- Electrical Evaluation. These include:
 - Upgrades to the breakers at MCC-B and the upstream substation (Unit Substation No.3)
 - New conductors and conduit/cable between the substation No. 3 and MCC-B



APPENDIX A

WQS Preliminary Design Schematics and Technical Memorandum

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Preliminary Design Report for Sweetwater Reservoir Aeration System

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1 Executive Summary

This technical memorandum summarizes the basic parameters of the underwater portion of an aeration system for Sweetwater Reservoir. It includes two options of preliminary diffuser system design and provides general guidelines for system operation. This memo is prepared by Water Quality Solutions Inc. (WQS), on behalf of Hazen and Sawyer and the Sweetwater Authority (SWA). Hazen and Sawyer is performing the preliminary design for the onshore components and the final design for the entire system.

Sweetwater Reservoir is located near Spring Valley, CA, and is owned and operated by the SWA, and supplies water to the Perdue Water Treatment Plant. Sweetwater Reservoir experiences anoxia (low dissolved oxygen, or DO) at depth during the summer months, a result of oxygen demand by sediments and weak vertical mixing. Anoxia has increased in recent years, with a significant portion of the reservoir experiencing low DO in 2018 and 2019.

In 2020, Gillingham Water and WQS conducted a study and provided several alternatives for water quality improvement in Sweetwater Reservoir (Gillingham Water, 2020). On the basis of the cost/benefit analysis, the SWA selected destratification by aeration as the preferred alternative in year 2021.

In this memo bubble tube diffusers are proposed as the aeration system. In the last 20 years many installations have employed bubble tube diffusers. The proposed air diffuser design for underwater portion of the diffusers consists of two HDPE pipes: one 3-inch air supply pipe that discharges the air at regular intervals from the air pipe, as well as a larger 4-inch buoyancy pipe. The buoyancy pipe is laid in parallel to the air supply line, and the pipes are fastened to each other. When the buoyancy pipe is full of water, the diffuser is designed to sink. To retrieve the system to the surface, air is pumped into the buoyancy line to displace the water. Air for the diffuser will be fed into the supply pipe from a compressor that will be sized by Hazen and Sawyer.

In this memo, two options of the diffuser system are presented: one 500-feet (ft) diffuser line, or one 2,000-ft diffuser line. Both options would employ the same above-water and subaqueous supply lines, and would originate just east of the log boom. These system locations would be located in the deepest and flattest part of the reservoir, maximizing the upwelling of hypolimnetic water to the epilimnion and providing even air flow throughout the length of the diffuser. The diffuser lengths and elevations are shown in **Table 1.1**. The estimated costs for the two options are also listed in the table. Cost estimates listed here are strictly for the submerged portions of the system and do not include compressors or any above water components. The 500-ft and 2000-ft diffusers are estimated to cost approximately \$241,000 and \$350,000, respectively. The cost difference (\$109,000) of the two diffuser options is not proportional to the length difference

of the two diffuser options, because the most significant portion of the cost is on the base cost (equipment rental, construction, etc).

Table 1.1 Diffuser Layout^{1,2,3} and Cost

Diffuser Length (ft)	Diffuser Elevation (ft)		Estimated Cost ⁴
	Beginning of Diffuser	End of Diffuser	
500	179	180	\$241,000
2000	179	182	\$350,000

1. Minimum Pool = 189 ft
2. Minimum Operational Level = 196.6 ft
3. Diffuser to be suspended ~3 ft off bottom and should remain underwater
4. Includes materials, labor, contractor markup, and contingency for subaqueous air supply lines and diffusers.

The proposed system is designed to maintain destratified conditions under all storage conditions when operated continuously at full power. At a storage level of 20,000 acre-feet (a-f), this system sizing provides some flexibility such that the system can destratify the reservoir if stratification is allowed to develop. At lower storage levels of approximately 10,000 a-f and below, the system will provide additional benefits, including increased operational flexibility to operate the system at lower power or with interruptions, or to increase the degree of mixing to decrease cyanobacteria growth. An aeration system destratifies a reservoir through entraining water with an upward stream of bubbles. It brings deep, anoxic water to the surface that is replaced by downwelling of oxygenated surface water. This leads to oxygenated water with uniform water quality throughout the reservoir, which decreases hydrogen sulfide (H₂S) and manganese levels and decreases internal nutrient cycling.

The next step is for the SWA to select one diffuser system from the two options. If the 2000-ft diffuser option is chosen, it can be converted to a hypolimnetic oxygenation system (HOS) later if needed. The 2000-ft diffuser may also provide better control of cyanobacteria growth in the reservoir than the 500-ft diffuser.

2 Introduction

This technical memorandum summarizes the basic parameters of the underwater portion of an aeration system for Sweetwater Reservoir. It includes the two options of preliminary diffuser system design and provides general guidelines for system operation. This memo is prepared by Water Quality Solutions Inc. (WQS), on behalf of Hazen and Sawyer and the Sweetwater Authority (SWA).

The organization of this report is as following:

- **Section 2** provides overview of previous studies and general water quality information of Sweetwater Reservoir;
- **Section 3** provides discussions of diffuser specifics;
- **Section 4** presents flow calculations;
- **Section 5** provides general guidelines for system operation;
- **Section 6** presents preliminary cost estimate for the diffusers;
- **Section 7** presents the conclusions;
- **Section 8** presents references cited in this report
- **Section 9** presents the figures of this report.

2.1 Reservoir Description

Sweetwater Reservoir is located near Spring Valley, CA and has a maximum storage capacity of 28,079 acre-feet (a-f) and maximum water surface elevation (WSEL) of 239 feet (ft, **Figure 2.1**). At maximum capacity, the reservoir has an area of 936 acres. Sweetwater Reservoir is owned and operated by the SWA, and supplies water to the Perdue Water Treatment Plant. The reservoir receives inflows from three sources: runoff, imported water from the San Diego County Water Authority, and water released from Loveland Reservoir. Releases from Loveland Reservoir account for much of the inflow, and generally occur during winter. The quantity of releases depends on storage available in Loveland Reservoir. In the period from 2002 to 2020, the storage in Sweetwater Reservoir varied from 2,800 to 23,200 a-f (**Figure 2.2**)

2.2 Water Quality in Sweetwater Reservoir

Lakes such as Sweetwater Reservoir generally exhibit thermal stratification that is controlled by meteorological variables such as air temperature, solar radiation, and wind. As air temperature and solar radiation increase in the spring and summer, a thermocline develops as illustrated in **Figure 2.3**. In the fall and winter, decreasing air temperature and solar radiation cool the surface water and deepen the thermocline until turnover, the time when a reservoir becomes un-stratified and vertical mixing is uninhibited by stratification. The timing of turnover in a reservoir is affected by meteorological variables as well as reservoir depth.

A by-product of thermal stratification is the inhibition of oxygen transfer from the atmosphere to the hypolimnion. Historically, this generally resulted in anoxic conditions in the hypolimnion of Sweetwater Reservoir. Sweetwater Reservoir experiences anoxia (low dissolved oxygen, or DO) at depth during the summer months, a result of oxygen demand by sediments and weak vertical mixing (**Figure 2.4**). In general, DO levels are directly dependent on the development of the thermocline, phytoplankton activity, and sediment oxygen demand. Anoxia has increased in recent years, with a significant portion of the reservoir experiencing low DO in 2018 and 2019 (**Figure 2.5**). Anoxia can have significant implications for water quality, including high manganese and iron levels, nutrient release from sediment, and cyanobacteria growth.

2.3 Selection of Destratification by Aeration by SWA

In the previous study by Gillingham Water and WQS (Gillingham Water, 2020), several alternatives for water quality improvement in Sweetwater Reservoir were evaluated: hypolimnetic oxygenation (Speece Cone, SDOX, and diffused oxygenation), destratification by aeration, and vigorous mixing. On the basis of the cost/benefit analysis, the SWA selected destratification by aeration as the preferred alternative in year 2021.

2.4 Aeration Benefits

A destratification system destratifies a reservoir through entraining water with an upward stream of bubbles. It brings deep, anoxic water to the surface that is replaced by downwelling of oxygenated surface water (**Figure 2.6**). This leads to oxygenated water with uniform water quality throughout the reservoir, which decreases hydrogen sulfide (H_2S) and manganese levels and decreases internal nutrient cycling. However, by providing uniform water quality, vertical mixing reduces benefits of selective withdrawal. Reservoir water quality may be adversely affected during the start-up period. Quagga mussel growth may also increase. Destratification can be achieved in Sweetwater Reservoir through the use of a line diffuser near the deepest part of the reservoir

2.5 Modeling and System Sizing

As part of the previous study by Gillingham Water and WQS (Gillingham Water, 2020), WQS modeled the reservoir with the Dynamic Reservoir Simulation Model program (DYRESM) under several simulated conditions. DYRESM is a one-dimensional hydrodynamics model developed at the former Centre for Water Resources at the University of Western Australia that treats a lake as a horizontally homogeneous water body and computes the vertical variations in temperature, salinity, and other variables. The model for Sweetwater Reservoir was calibrated using data from the period January 1, 2016 to December 31, 2019. This calibration involved changing some model parameters to obtain the best agreement with water surface elevation and temperature field data.

In the first simulation, the reservoir was simulated with the actual storage and flow conditions from the 2016-2019 period with 680 standard cubic feet per minute (scfm) of airflow (**Figure 2.7**). It was found that 680 scfm is sufficient to destratify the reservoir under the actual flow and storage conditions during this period. In the second simulation, the reservoir was simulated at 25,000 a-f with an airflow of 680 scfm (**Figure 2.8**). In this simulation the aeration system was started on July 1, after thermal stratification had begun. The airflow of 680 scfm was sufficient to destratify the reservoir over the course of approximately two months. In the third simulation, the reservoir was simulated at 5,000 a-f with various compressor powers (**Figure 2.9**). It was found that a compressor with more than 272 scfm (40 actual cubic feet per minute (acfm) @ 100 psi) would be needed to destroy the thermal stratification under this condition.

Based on these modeling results and the resulting feasibility study, the SWA selected a system sizing of 20,000 a-f as the basis for design. The SWA determined that a system sized for this volume would still be mostly, if not fully, effective at mixing the reservoir at full storage, and additional costs for upsizing the system to provide full functionality for low probability storage volumes would not be warranted. The previous modeling work (Gillingham Water 2020) demonstrated that an airflow of 680 scfm would provide sufficient mixing to maintain destratification at all reservoir levels if operated without interruption, and to destratify the reservoir at 20,000 a-f if some stratification is allowed to develop. Additional operational modeling was done under the present work, and will be described in **Section 5**.

3 Diffuser Design

3.1 Previous Installations and Types

Reservoir destratification can be achieved by a number of methods, including: water jets, turbines, pumping, surface mixing, and aeration. Of these methods, aeration has become the preferred strategy due to its effectiveness and robustness. Aeration has been achieved in reservoirs in various ways (**Table 3.1**). Early systems employed PVC or metal pipes with holes drilled directly in the pipe, which would be anchored to the reservoir bottom. These perforated pipe systems could either be designed as a point source, or as a linear diffuser (**Figure 3.1**). Some early systems such as Lake Baldegg also used membrane diffuser tubes in place of perforated pipes (**Figure 3.2**, Wuest 1992). More recently, some installations have employed membrane disc diffuser designed for use in wastewater treatment (**Figure 3.3**). However, these early systems suffered from issues such as orifice clogging and membrane deterioration.

Many installations in the last 20 years have employed bubble tube diffusers (**Figure 3.4**). These systems consist of an HDPE air supply pipe that outputs air into a porous hose. The air supply pipe is connected to a buoyancy pipe for installation and maintenance, and the system is anchored to the reservoir bottom by a concrete anchor and stainless steel cables. The flexible porous hose has been shown to resist clogging in lakes in reservoirs over various installations (Mobley et al., 2019).

3.2 System Length and Location

In this memo, two options of the diffuser system are presented: one 500-ft diffuser line, or one 2,000-ft diffuser line. Both options would employ the same above-water and subaqueous supply lines, and would originate just east of the log boom (**Figure 3.5**). These system locations would be located in the deepest and flattest part of the reservoir, maximizing the upwelling of hypolimnetic water to the epilimnion and providing even air flow throughout the length of the diffuser. The diffuser lengths and elevations are shown in **Table 3.2**. This location also minimizes impacts to deeper sediments near the outlet tower, and does not require removal of the log boom during installation or maintenance.

The next step is for the SWA to select one diffuser system from the two options. If the 2000-ft diffuser option is chosen, it can be converted to a hypolimnetic oxygenation system (HOS) later if needed. The 2000-ft diffuser may also provide better control of cyanobacteria growth in the reservoir than the 500-ft diffuser.

Table 3.1 Select Previous Aeration Systems

Lake	Year	Surface Area (acres)	Aerator Type	Air Flow (scfm)	Notes	Citation
Babson Reservoir	1961	40	Point aerator	700		Nickerson, 1961
El Capitan Reservoir	1968	1,500	102 ft perforated pipe	1,000		Fast, 1968
Wallop Lake	1981	90	One 1 hp surface aerator	0.5*		Ashley, 1987
Lake Baldegg	1982	1,300	Six point diffusers	120	Pure oxygen used in summer	Wuest et al.,1992
Lake Langford	1984	150	One point diffuser (perforated pipe)	65		Ashley, 1987
North Pine Dam	1990	4,900	1800 ft perforated pipe	425*		Antenucci et al., 2005
Spring Hollow Reservoir	2004	150	3,500 ft bubble tube diffuser	170	Partially Retrofitted to use pure oxygen	Gantzer et al., 2009
Lake Casitas	2005	1,100	16 surface-suspended diffuser tubes	250	Design evolved multiple times since 1968	Mobley et al., 2019
Cherry Creek Reservoir	2008	900	102 membrane disc diffusers	455	Poor performance and maintenance issues	WWE, 2020
Ni River Reservoir	2018	417	9,340 ft bubble tube diffuser	Unknown		Mobley Engineering
Peace River #1	2008	85	3,630 ft bubble tube diffuser	200		Mobley Engineering
Peace River #2	2010	650	12,240 ft bubble tube diffuser	750		Mobley Engineering
CW Bill Young	2014	1,100	15,000 ft bubble tube diffuser	1,200		Mobley Engineering
Boyette	2015	80	bubble tube diffuser	Unknown		Mobley Engineering
Bambei-Walker	2018	50	2,900 ft bubble tube diffuser	Unknown		Mobley Engineering
Welby	2018	45	2,590 ft bubble tube diffuser	Unknown		Mobley Engineering
Dunes	2018	100	3,990 ft bubble tube diffuser	Unknown		Mobley Engineering
Tanabe	2018	35	2,520 ft bubble tube diffuser	Unknown		Mobley Engineering
Hooper	2019	143	bubble tube diffuser	Unknown		Mobley Engineering

*Flow rate not specified to be standard or actual

Table 3.2 Diffuser Layout^{1,2,3}

Diffuser Length (ft)	Diffuser Elevation (ft)		Elevation Difference (ft)
	Beginning of Diffuser	End of Diffuser	
500	179	180	1
2000	179	182	3

5. Minimum Pool = 189 ft
6. Minimum Operational Level = 196.6 ft
7. Diffuser to be suspended ~3 ft off bottom and should remain underwater

3.3 Bubble Tube Aeration System Description

The proposed air diffuser design for underwater portion of the diffusers consists of two HDPE pipes: one 3-inch air supply pipe that discharges the air at regular intervals from the air pipe, as well as a larger 4-inch buoyancy pipe. The buoyancy pipe is laid in parallel to the air supply line, and the pipes are fastened to each other every 15 ft. When the buoyancy pipe is full of water, the diffuser is designed to sink. To retrieve the system to the surface, air is pumped into the buoyancy line to displace the water. The pipelines are secured to the bottom using stainless steel cable and anchors. Typically, the diffusers are laid at the desired location on the water surface and then carefully lowered to the bottom by operating the buoyancy pipeline. Anchoring consists of concrete “flower pot” anchors attached to the air supply with 3 ft long stainless-steel cables every 15 ft.

Many recently installed diffusers are constructed using HDPE SDR11 air supply piping, and HDPE SDR 11, 13, or 17 buoyancy piping. HDPE is non-corrosive, light weight, and can be easily shaped on the reservoir surface to obtain the desired shape of the diffuser line. If HDPE piping is used, special care should be taken to ensure that the pressure rating of the pipe is not exceeded. Other pipe material (such as appropriate metal piping) can be used if a higher pressure-rating is needed.

Air is discharged from the air supply pipe through a connection between drilled air ports and porous tubing. The air supply line is coupled to the porous tubing as shown in **Figure 3.6**. This allows a nearly-uninterrupted curtain of bubbles from the diffuser across its entire length. These porous hoses have shown resistance to clogging in previous installations (Mobley et al. 2019). Typically, the porous hosing is replaced every 10 years.

The air plume will result in a significant, visible surface boil. An example of a visible surface plume is shown in **Figure 3.7**, with an air flow rate of 0.08 scfm/linear-ft. Note that the design flow rate for the 500-ft diffuser line and 2000-ft diffuser line in Sweetwater Reservoir will be 0.3-1.4 scfm/linear-ft depending on system selected, and will result in a more vigorous surface boil than the example shown.

When the aeration system is in operation, the piping system will stay at elevations of approximately 3 ft above the bottom. When not in operation, the piping system may

sink slightly but would not sink all the way to the sediment (personal communication with Mobley Engineering, 2022). Mobley Engineering has installed many systems that are operated intermittently (e.g., hydroelectric installations only operating in summer), which typically float 2 ft or more off the bottom when not in operation.

Air compressors with appropriate horse power will be needed to compress air and deliver air flow to the diffusers at depth. The compressor system should supply air with very low levels of oil contamination. If an oil-flooded compressor is used, a highly efficient oil coalescence filter should be used. If conversion to an HOS is desired in the future, a very efficient and reliable oil removal system, or an oil-free air compressor, is recommended. For this conversion, the pipes must be clean of oil and other contaminants for use with oxygen. An after cooler, sometimes coupled with an air dryer, may be needed downstream of the compressor to reduce the air temperature and prevent condensation in the air supply line.

3.4 Pipe Materials and Anchoring

Concrete anchors are attached to the diffuser assembly every 15 ft along the entire length of each diffuser, with coated stainless-steel cables and saddle connections (**Figure 3.4**). These anchors are used to sink the pipe system and hold it in position near the bottom of the lake. The diffuser pipe can be held at the desired distance off the bottom of the lake by using custom anchor cable lengths. In the current design, a 3 ft cable is specified.

The anchors are made from concrete-filled plastic flower pots. The weight of the concrete anchors, plus the weight of the pipes, can be supported by the buoyancy pipe filled with air and float on the water surface during installation and maintenance. The weight of the anchors is to be determined so that the diffusers are securely held in place at all times after installation and during operation. Based on past experience, an anchor weight of approximately 120 pounds is needed. The weight specification of anchors should be re-visited as the engineering design is finalized.

3.5 Installation

Diffuser Assembly typically occurs on land. Diffuser pipe sections, usually 15 ft in length, and fittings may be joined together or to other materials by heat fusion (HDPE pipe) joining or mechanical joining (**Figures 3.8 and 3.9**). Assembled diffuser sections can be lowered towards water and pulled over the lake using work boats. If the diffuser assembly is stored on the water surface, the diffuser assembly should be anchored and secured to the shoreline with strong ropes or fasteners to prevent damage and avoid creating a boating hazard. All assembly operations on the lake shall be restricted to times or areas of the lake where public boating and access is limited.

Upon completion of diffuser assembly, the diffuser should be floated from the construction site to the location where installation is specified (**Figures 3.10 and 3.11**). The sections of the lake in the vicinity of the diffuser locations should have been identified and marked using the global positioning system (GPS) and sonar or other underwater topographical mapping equipment such as Lowrance or equivalent. The purpose of the survey is to identify the bathymetric contours at which the various diffusers are to be installed. The diffusers shall be moved into position and secured with appropriate lines and mooring at the beginning, diffuser turns, and end. Once in position and secured, the buoyancy pipeline should be slowly flooded starting from the upstream end to sink the diffuser in a controlled manner to the lake bottom. Note that, typically, a portable compressor is used for this task. As it sinks, the position of the diffuser should be monitored to ensure proper positioning when it reaches the bottom. Once an entire diffuser is resting on the bottom, the diffuser position should be inspected and evaluated to ensure optimal placement. If the diffuser is not positioned properly, the diffuser shall be raised, repositioned and sunk again. As a result of the complexity of the diffuser installation process, it is recommended that the diffuser consist of no more than a few straight sections.

After installation, the air supply system should be tested at design flow and pressure measured with onsite instrumentation to assure adequate air flow is being delivered to the diffusers and lake water. The diffusers will also be inspected to assure correct bubble patterns once in position, indicating even air flow along the entire diffuser length. If large leaks or dead spots are evident on the surface, the diffuser should be refloated and repaired.

4 Flow Calculations

4.1 Fluid Dynamics

The air flow through an orifice is calculated based on the orifice diameter, the supply pressure, and the back pressure at the orifice. The back pressure is determined by the depth of the water column above the diffuser. The flowrate from each orifice depends on the depth of the orifice and distance along the pipe. To determine the flow uniformity across the length of a diffuser, air flow calculations at each orifice are required. Note that decreasing the orifice diameter increases airflow uniformity and increases the pressure drop across the orifice. A diffuser operated at a higher pressure may require the use of a higher pressure-rated pipe and a larger compressor, potentially complicating the construction process and resulting in tighter specifications.

The manifold calculation methodology of air flow along a diffuser is solved following Chapter 10.3 (Outfall and Diffuser Hydraulics) of Book "Mixing in Inland and Coastal Waters" (Fischer et al., 1979). The method is modified to account for air compressibility. The air flow through an orifice or drilled hole, under choked or non-choked conditions, is calculated from Bernoulli's equation, assuming steady-state. The unchoked air flow rate is given by (Perry and Green, 1984):

$$\dot{m} = C_d A \sqrt{2 \rho_1 P_1 \left(\frac{k}{k-1} \right) \left[(P_2/P_1)^{2/k} - P_2/P_1^{(k+1)/k} \right]}$$

and the choked air flow rate is given by (Perry and Green, 1984):

$$\dot{m} = C_d A \sqrt{k \rho_1 P_1 \left(\frac{2}{k+1} \right)^{(k+1)/(k-1)}}$$

where:

$\dot{m}$ = mass flow rate (kg/s)

C_d = discharge coefficient

A = discharge hole cross-section area (m²)

ρ_1 = upstream real gas density (kg/m³)

P_1 = upstream gas pressure (Pa)

P_2 = downstream pressure (Pa)

k = specific heat ratio (1.4).

The head loss along the air supply pipe due to friction is calculated from the Darcy-Weisbach equation (Mays, 1999):

$$h_f = \frac{f L v^2}{2 D g}$$

where:

h_f = head loss (ft or m)

f = Darcy friction factor

L = pipe length (ft or m)

v = velocity (ft/sec or m/sec)

D = pipe diameter (ft or m)

g = gravitational acceleration (32.2 ft/sec² or 9.81 m/sec²).

Small orifices or drilled holes need to be used in order to evenly distribute air flow along the diffuser. Several assumptions were used in the calculations: isentropic flow along the diffuser pipe, HDPE absolute roughness = 0.00006 inches, discharge coefficient $C_d = 0.6$ for drilled holes, air temperature at diffuser end of 70 degrees F. These preliminary calculations assume a compressor flow rate of 680 scfm. The flow calculations will be reviewed, and recommendations updated by WQS, after the final selection of the compressors, diffuser line length, piping, and various other parts of the system. If the flow rate of the selected compressor varies significantly from 680 scfm, orifice diameters may also need to be redetermined.

4.2 Orifice Diameter and Flow Uniformity Results

The air diffuser consists of a 500- or 2,000-ft diffuser line fed by a 600-ft subaqueous supply pipe. The diffuser line will consist of a 3-inch (nominal) HDPE pipe joined to a 4-inch (nominal) HDPE buoyancy line as described above. The air supply line will feed air through drilled orifices spaced every 15 ft.

The diffuser dimensions and air flow requirements are given in **Table 4.1** for the 500 ft diffuser option. If a port diameter of 0.234 inches is used, the required supply pressure at the beginning of the diffuser is 44 psia (pounds per square inch absolute) at low WSEL (196.6 ft) and 51 psia at high WSEL (239 ft), and the resulting flow difference is $\pm 3\%$ or $\pm 4\%$ for the low WSEL and high WSEL scenarios (**Table 4.2**).

The diffuser dimensions and air flow requirements are given in **Table 4.3** for the 2,000 ft diffuser option. If a port diameter of 0.104 inches is used, the required supply pressure at the beginning of the diffuser is 59 psia (pounds per square inch absolute) at low WSEL (196.6 ft) and 61 psia at high WSEL (239 ft), and the resulting flow difference is $\pm 7\%$ or $\pm 9\%$ for the low WSEL and high WSEL scenarios (**Table 4.4**).

Table 4.1 500-ft Linear Diffuser

Diffuser Pipe Length (ft)	500
Internal Diameter of Diffuser Pipe ¹ (in)	3(2.83)
Total Air Flow (scfm)	680
Underwater Supply Pipe Length (ft)	600
Internal Diameter of Underwater Supply Pipe ¹ (in)	3(2.83)
Above-Water Supply Pipe Length (ft)	813
Internal Diameter of Above-Water Supply Pipe ¹ (in)	4(3.63)
Port Spacing (ft)	15
Number of Ports	34
Port Diameter (in)	0.234
Diffuser Height above Bottom (ft)	3
Water Surface Elevation (ft)	196.6 or 239
Air Temperature at Diffuser End (°F)	70
Diffuser Elevation (ft)	179-180

1. Value format: nominal(actual)

Table 4.2 Calculated Air Flow of 500-ft Linear Diffuser

Reservoir Storage (a-f)	WSEL (ft)	Supply Pressure (psia)			Flow Difference ¹	Air Compressor Horsepower Needed ²
		Compressor Outlet	Beginning of underwater supply pipe	Beginning of Diffuser		
3350	196.6	53	51	44	±3%	79
28,079	239	60	57	51	±4%	87

1. Flow difference defined as $\text{Max}[|Q_{\text{max}} - Q_{\text{mean}}|, |Q_{\text{min}} - Q_{\text{mean}}|]/Q_{\text{mean}} \times 100\%$

2. One-stage of compression and 85% compressor efficiency are assumed

Table 4.3 2000-ft Linear Diffuser

Diffuser Pipe Length (ft)	2000
Internal Diameter of Diffuser Pipe ¹ (in)	3(2.83)
Total Air Flow (scfm)	680
Underwater Supply Pipe Length (ft)	600
Internal Diameter of Underwater Supply Pipe ¹ (in)	3(2.83)
Above-Water Supply Pipe Length (ft)	813
Internal Diameter of Above-Water Supply Pipe ¹ (in)	4(3.63)
Port Spacing (ft)	15
Number of Ports	134
Port Diameter (in)	0.104
Diffuser Height above Bottom (ft)	3
Water Surface Elevation (ft)	196.6 or 239
Air Temperature at Diffuser End (°F)	70
Diffuser Elevation (ft)	179-182

1. Value format: nominal(actual)

Table 4.4 Calculated Air Flow of 2000-ft Linear Diffuser

Reservoir Storage (a-f)	WSEL (ft)	Supply Pressure (psia)			Flow Difference ¹	Air Compressor Horsepower Needed ²
		Compressor Outlet	Beginning of underwater supply pipe	Beginning of Diffuser		
3350	196.6	67	64	59	±7%	96
28,079	239	69	67	61	±9%	99

1. Flow difference defined as $\text{Max}[|Q_{\text{max}} - Q_{\text{mean}}|, |Q_{\text{min}} - Q_{\text{mean}}|]/Q_{\text{mean}} \times 100\%$

2. One-stage of compression and 85% compressor efficiency are assumed

5 Guidelines for System Operation

5.1 General Considerations

It is more difficult to destratify a reservoir at larger volumes than at smaller volumes. To understand the system performance under various reservoir volumes, scenarios were modeled in which stratification was allowed to develop, and the aeration system was then started.

If the aeration system is started during the stratified season, the length of time that it takes to mix the reservoir depends on the reservoir's storage at that time. **Figure 5.1** demonstrates the approximate time that it may take to mix the reservoir for various reservoir storages, assuming the aeration system is started on July 1, when the stratification is strong. For a 5,000 a-f storage, it takes approximately three weeks for the reservoir to be destratified; while for a 25,000 a-f storage, it takes approximately eight weeks for the reservoir to be destratified (**Table 5.1**). Destratification is defined here as a difference in temperature $< 2^{\circ}\text{C}$ between the surface and the elevation 5 ft from bottom. While there are no universally-established criteria for characterizing stratification, this metric captures mixing of the surface layer to a depth below the lowest usable port. The existing thermocline was destroyed much sooner than the destratification times listed above. Note that these destratification times were estimated under the condition of strong stratification. If the aeration system is started in the condition of weak or no stratification, the reservoir will be destratified significantly faster. Therefore, the aeration system should be operated continuously to achieve the goal of destratification.

Table 5.1 Days to Destratify Reservoir for Various Storage Conditions

Reservoir Storage (a-f)	Days to Destratify Reservoir ¹	
	340 scfm airflow	680 scfm airflow
5,000	38	23
10,000	50	46
25,000	71	56

1. Destratification defined as a difference in temperature $< 2^{\circ}\text{C}$ between the surface and the elevation 5 ft from bottom

5.2 Specific Recommendations

The aeration system can be turned down during the unstratified period of each year in order to save energy. The system may also need to be turned off completely for quagga mussel control. For best results, the aeration system would be operated year-round. For cost efficiency, the aeration system could be started before stratification sets in, around mid-February and continued in operation through end of December.

Note that it requires more energy to destratify a reservoir in strong stratification than to keep an unstratified reservoir mixed. In cases where the aeration system is shut down for a period of time during the stratified season for certain reasons, such as quagga

mussel control, the aeration system needs to be turned on as soon as the goal is reached. If the reservoir is allowed to stratify for an extended period of time, restarting the aeration system may cause nutrient-rich anoxic water from the hypolimnion to mix upwards, resulting in possibly severe algal blooms and a period of decreased water quality throughout the reservoir.

The aeration system can be operated in various ways under different storage conditions. For example, at low storage (below 10,000 a-f), if there are no water quality issues, the two air compressors may not need to be in continuous simultaneous operation for 24 hours a day, in order to save energy cost. At storage above 10,000 a-f, two air compressors are needed to be in full operation during the warmer months (May through October), and one compressor may be needed in full operation during the cooler months (November through April) that can be augmented as water quality issues arise. At high storage (above 20,000 a-f) and with good water quality, the system may be turned off if the reservoir is to be sustained at high storage levels throughout the year. Note, however, that if the reservoir storage is to drop significantly during the summer while the system is not operating, starting the compressors in the summer may cause algal blooms and the compressors may not be able to rapidly destratify the reservoir. The system can be turned off if and only if the water quality is good and oxygenated water can be reliably withdrawn from the higher ports. **Table 5.2** summarizes suggested operations for various storage conditions of the reservoir. These operational scenarios represent general guidelines, and the SWA should evaluate temperature and DO profile data to refine these guidelines. Frequent monitoring would be desirable to optimize the operation of the aeration system.

When the reservoir storage is low, it is possible to have only one air compressor in operation and still keep the reservoir destratified (**Figure 5.1**). In that case, the energy used is only approximately half of the energy needed when both air compressors are in operation. **Figure 5.2** demonstrates an example that under half power, the reservoir can still be mixed well within approximately five weeks, assuming the aeration system is started on July 1 (strong stratification), with only one air compressor is in operation. Under the condition of weak stratification, the reservoir will be destratified much faster, even with only one air compressor in operation.

Table 5.2 Example Aeration System Operations for Various Storage Conditions

Reservoir Storage (a-f)	Aeration System Operation ^{1, 2}
Above 20,000	With good water quality, the system may be turned off if the reservoir is to be sustained at high storage levels throughout the year. Note, however, that if the reservoir storage is to drop significantly during the summer while the system is not operating, starting the compressors in the summer may cause algal blooms and the compressors may not be able to rapidly destratify the reservoir.
Above 10,000	Two air compressors in full operation during the warmer months ³ ; one compressor in full operation during the cooler months ³ that can be augmented as water quality issues arise.
Below 10,000	One compressor in full operation most of the time. Two compressors in operation during water quality episodes.

1. During any time when a cyanobacteria bloom occurs, the SWA may want to operate the aeration system at high power to limit or reduce cyanobacteria growth.
2. These guidelines represent an estimate of operation needed to maintain reservoir destratification. The SWA will need to monitor reservoir stratification and increase the air flow rate if the stratification is not well-maintained at lower flows. Frequent monitoring would be desirable to optimize the operation of the aeration system.
3. Warmer months refer to May to October of each year, and the remainder of each year are considered cooler months.

6 Cost Estimate

Cost estimates for the two diffuser options of the destratification system have been obtained from Mobley Engineering and are provided in **Table 6.1**. Cost estimates listed here are strictly for the submerged portions of the system and do not include compressors or any above water components. These costs are ~10% higher than those in the previous study (Gillingham Water, 2020) because of inflation and other factors. These cost estimates can be included in the total cost estimates of the destratification systems.

Table 6.1: Cost Estimates for Diffusers

Diffuser Length (ft)	Diffuser Cost ¹
500	\$241,000
2000	\$350,000

1. Includes materials, labor, contractor markup, and contingency for subaqueous air supply lines and diffusers.

7 Conclusions

This technical memorandum summarizes the basic parameters of the underwater portion of an aeration system for Sweetwater Reservoir. It includes the two options of preliminary diffuser system design and provides general guidelines for system operation. This memo is prepared by Water Quality Solutions Inc., on behalf of Hazen and Sawyer and the Sweetwater Authority (SWA).

In this memo bubble tube diffusers are proposed as the aeration system. In the last 20 years many installations have employed bubble tube diffusers. The proposed air diffuser design for underwater portion of the diffusers consists of two HDPE pipes: one 3-inch air supply pipe that discharges the air at regular intervals from the air pipe, as well as a larger 4-inch buoyancy pipe. Buoyancy pipe is laid in parallel to the air supply line, and the pipes are fastened to each other. When the buoyancy pipe is full of water, the diffuser is designed to sink. To retrieve the system to the surface, air is pumped into the buoyancy line to displace the water. Air will be fed into the supply pipe from a compressor that will be sized by Hazen and Sawyer.

In this memo, two options of the diffuser system are presented: one 500-ft diffuser line, or one 2,000-ft diffuser line. Both options would employ the same above-water and subaqueous supply lines, and would originate just east of the log boom. These system locations would be located in the deepest and flattest part of the reservoir, maximizing the upwelling of hypolimnetic water to the epilimnion and providing even air flow throughout the length of the diffuser. The diffuser lengths and elevations are shown in **Table 7.1**. The estimated costs for the two options are also listed in the table. Cost estimates listed here are strictly for the submerged portions of the system and do not include compressors or any above water components. The 500-ft and 2000-ft diffusers are estimated to cost approximately \$241,000 and \$350,000, respectively. The cost difference (\$109,000) of the two diffuser options is not proportional to the length difference of the two diffuser options, because the most significant portion of the cost is on the base cost (equipment rental, construction, etc).

Table 7.1 Diffuser Layout^{1,2,3} and Cost

Diffuser Length (ft)	Diffuser Elevation (ft)		Estimated Cost ⁴
	Beginning of Diffuser	End of Diffuser	
500	179	180	\$241,000
2000	179	182	\$350,000

1. Minimum Pool = 189 ft
2. Minimum Operational Level = 196.6 ft
3. Diffuser to be suspended ~3 ft off bottom and should remain underwater
4. Includes materials, labor, contractor markup, and contingency for subaqueous air supply lines and diffusers.

The proposed system is designed to maintain destratified conditions under all storage conditions when operated continuously at full power. At a storage level of 20,000 a-f, this system sizing provides some flexibility such that the system can destratify the reservoir if stratification is allowed to develop. At lower storage levels of approximately 10,000 a-f and below, the system will provide additional benefits, including increased operational flexibility to operate the system at lower power or with interruptions, or to increase the degree of mixing to decrease cyanobacteria growth. An aeration system destratifies a reservoir through entraining water with an upward stream of bubbles. It brings deep, anoxic water to the surface that is replaced by downwelling of oxygenated surface water. This leads to oxygenated water with uniform water quality throughout the reservoir, which decreases hydrogen sulfide (H_2S) and manganese levels and decreases internal nutrient cycling.

The next step is for the SWA to select one diffuser system from the two options. If the 2000-ft diffuser option is chosen, it can be converted to a hypolimnetic oxygenation system (HOS) later if needed. The 2000-ft diffuser may also provide better control of cyanobacteria growth in the reservoir than the 500-ft diffuser.

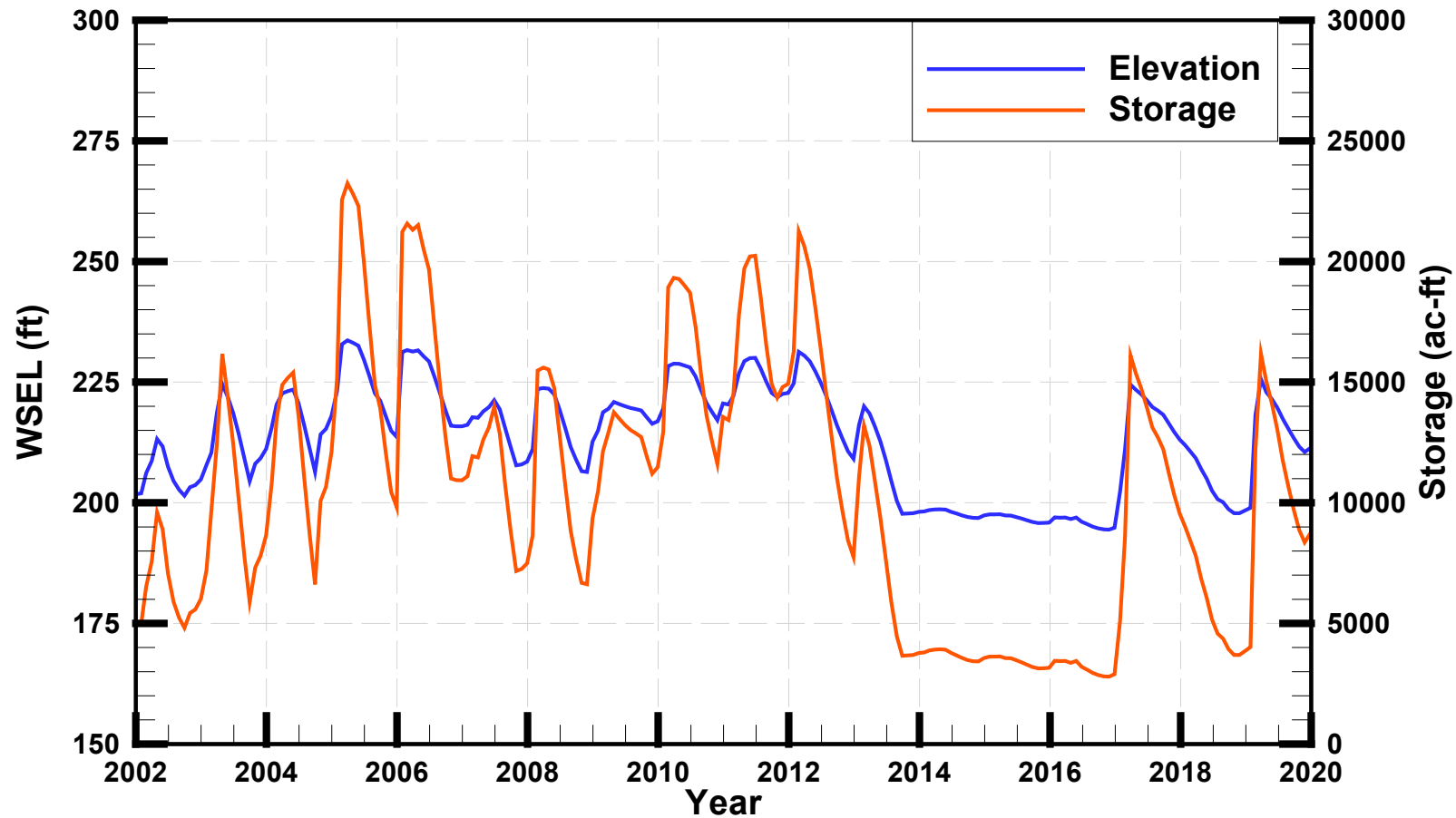
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9 Figures

Sweetwater Reservoir – WSEL and Volume

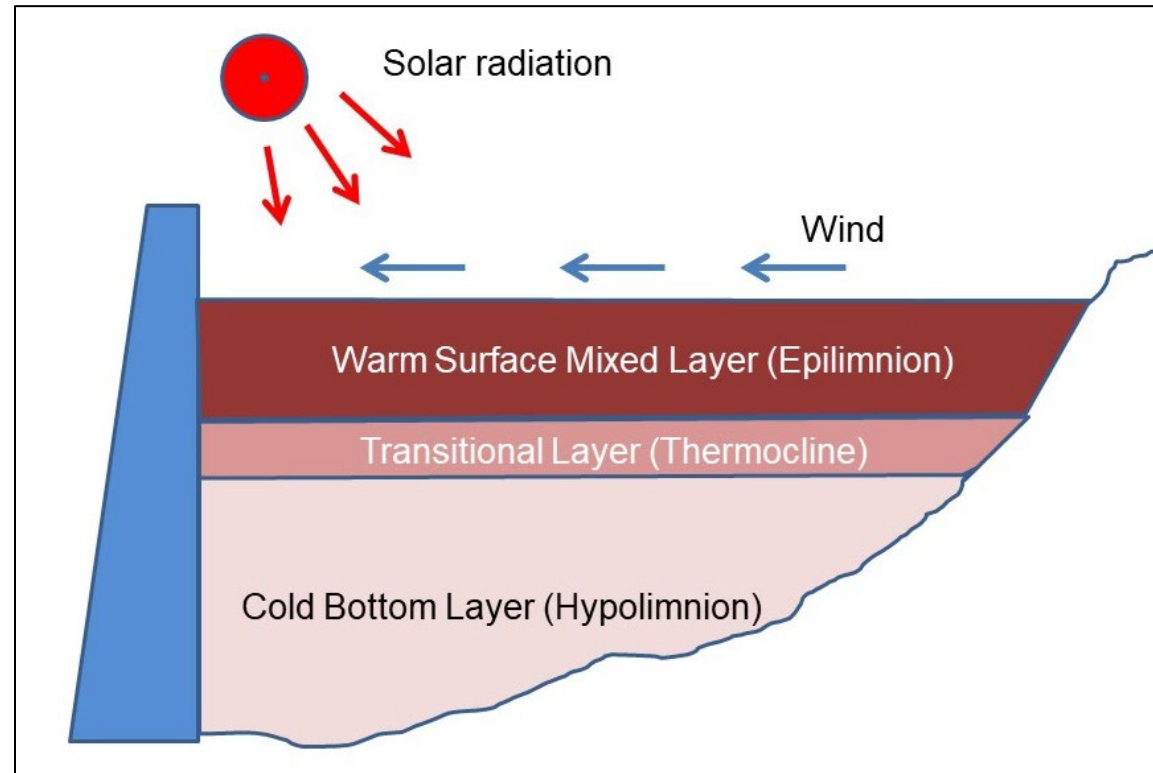
January 2002 to December 2019



Minimum WSEL $\approx$ 195 ft

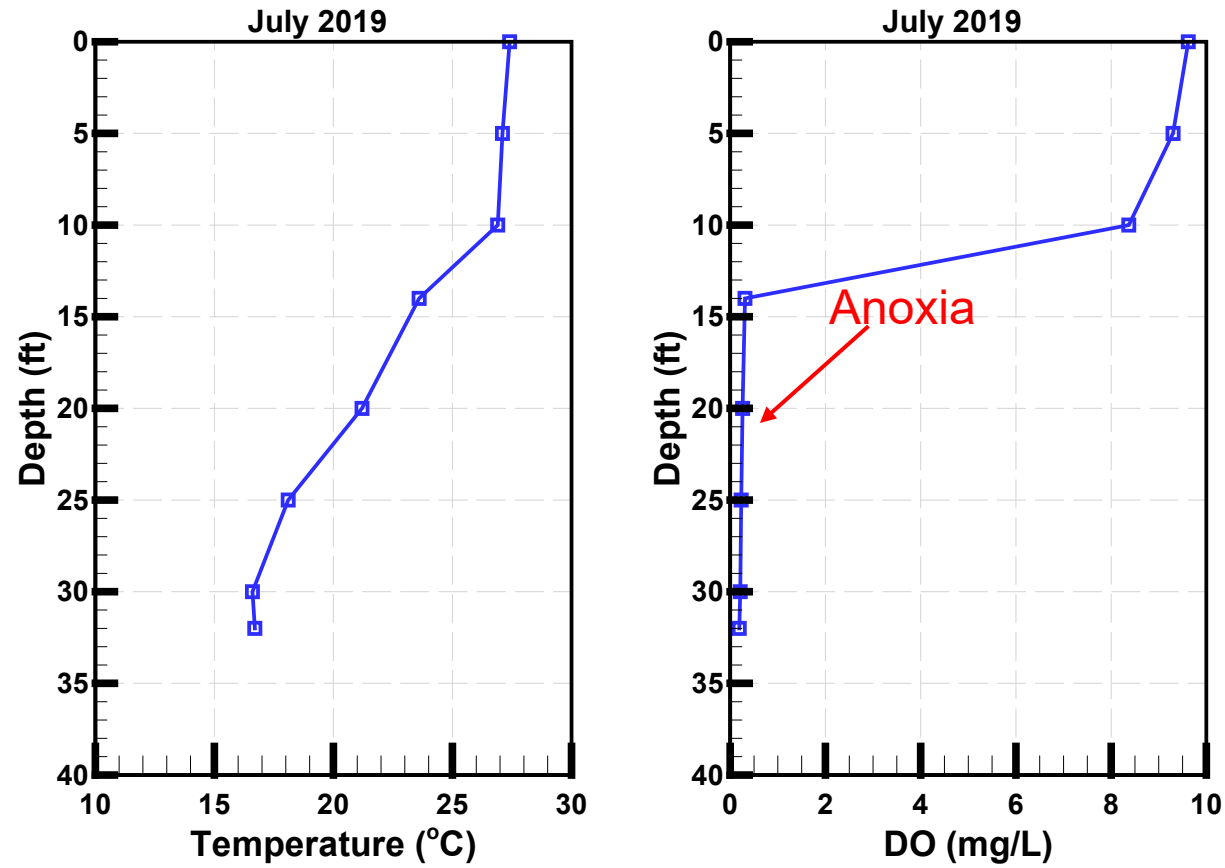
Source: "Engineering Monthly Report 2019_December (Recovered)".xls

Stratification in Lakes and Reservoirs



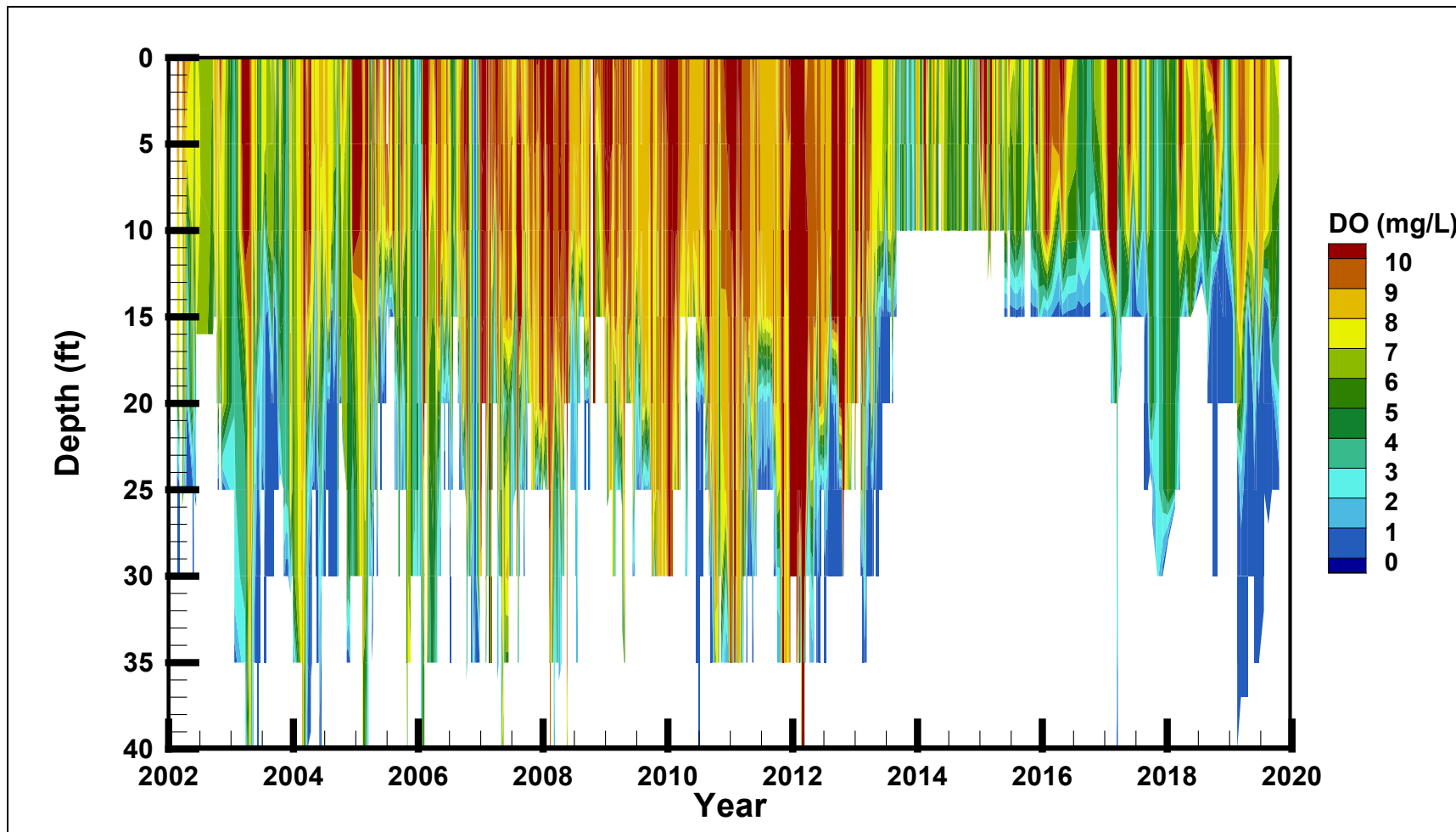
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Anoxia in Sweetwater Reservoir



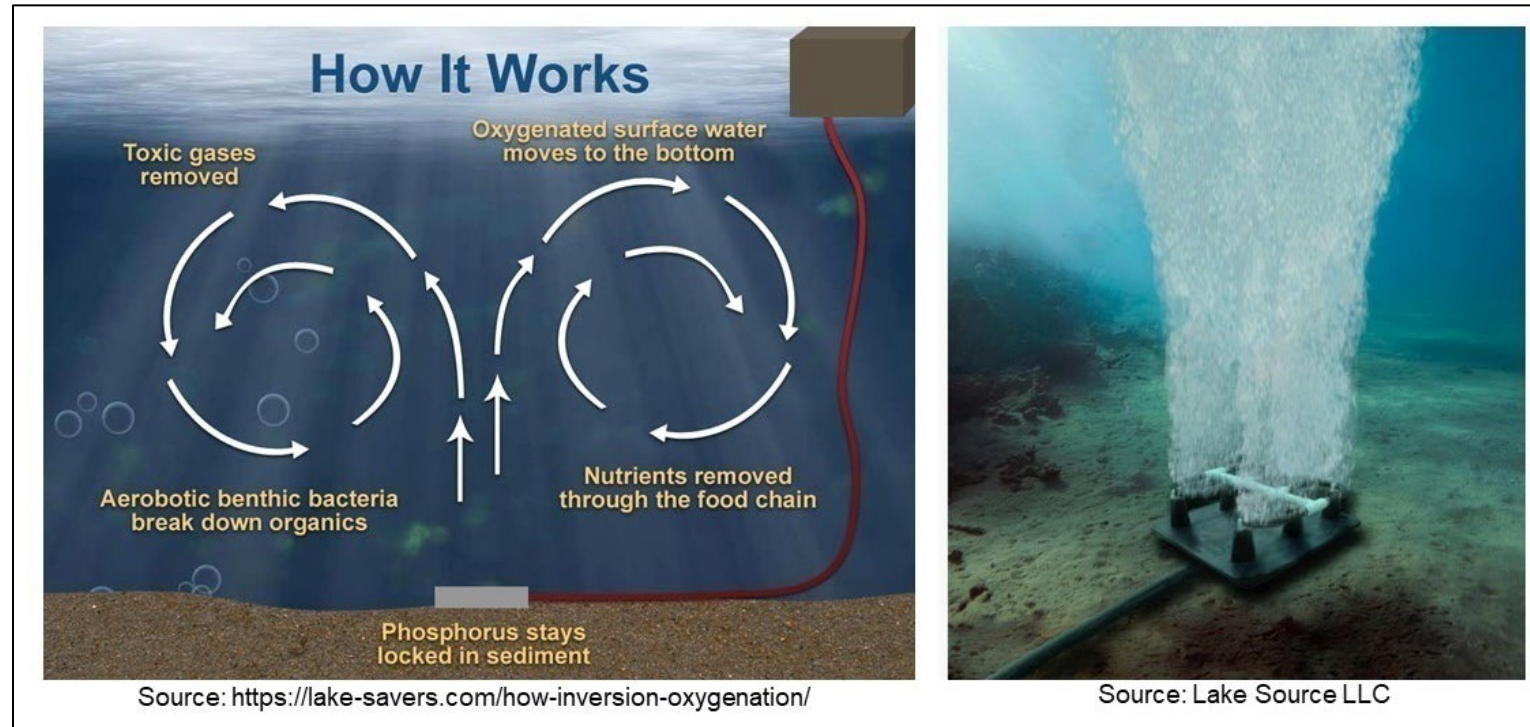
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Dissolved Oxygen in Sweetwater Reservoir



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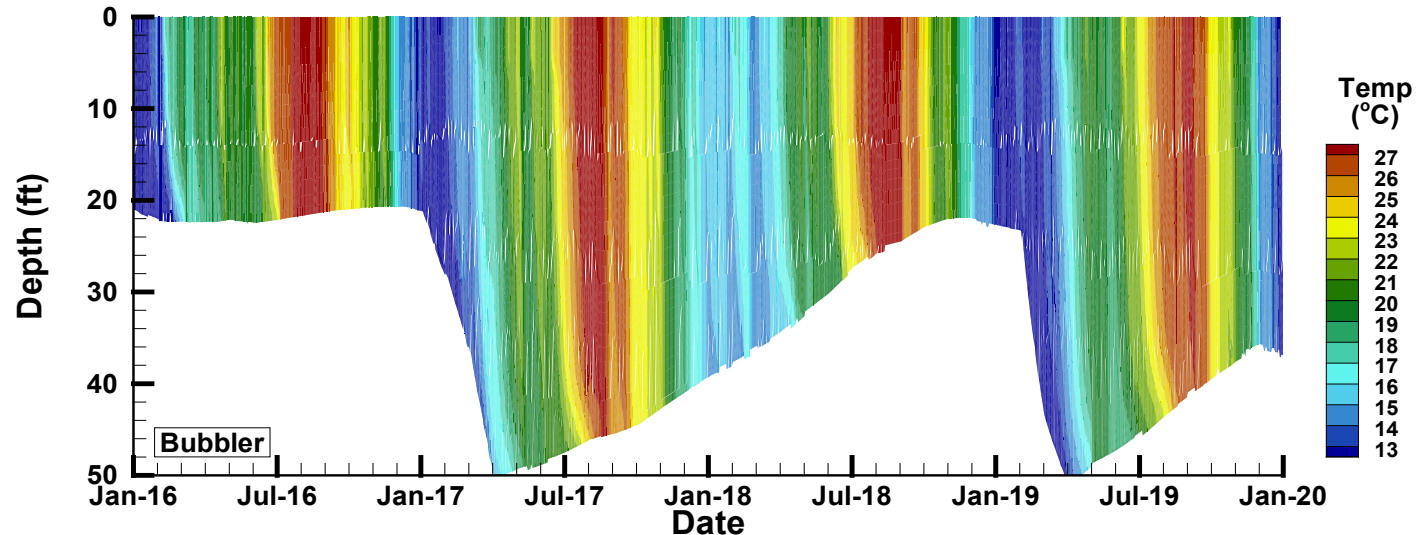
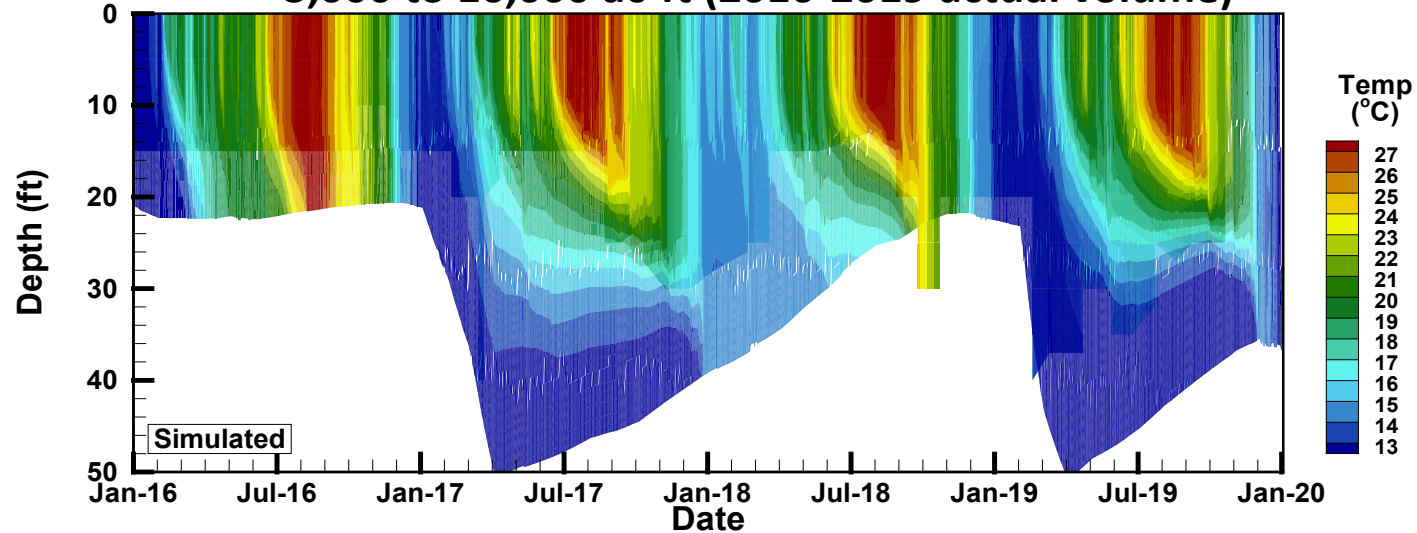
Aeration System



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Destratification Modeling: Actual Flow and Storage from 2016-2019

100 cfm @ 100 psi (680 scfm)
3,000 to 16,000 ac-ft (2016-2019 actual volume)

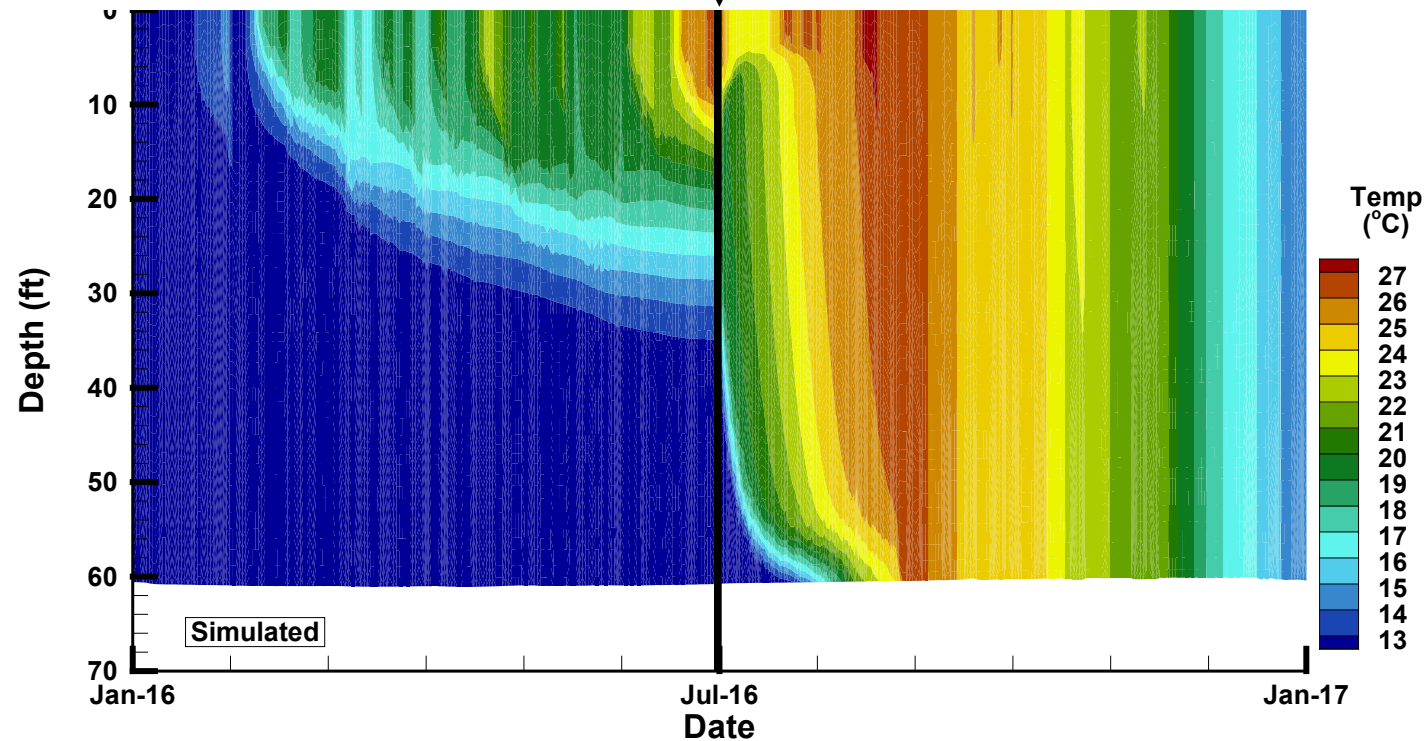


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Destratification Modeling: Storage = 25,000 a-f

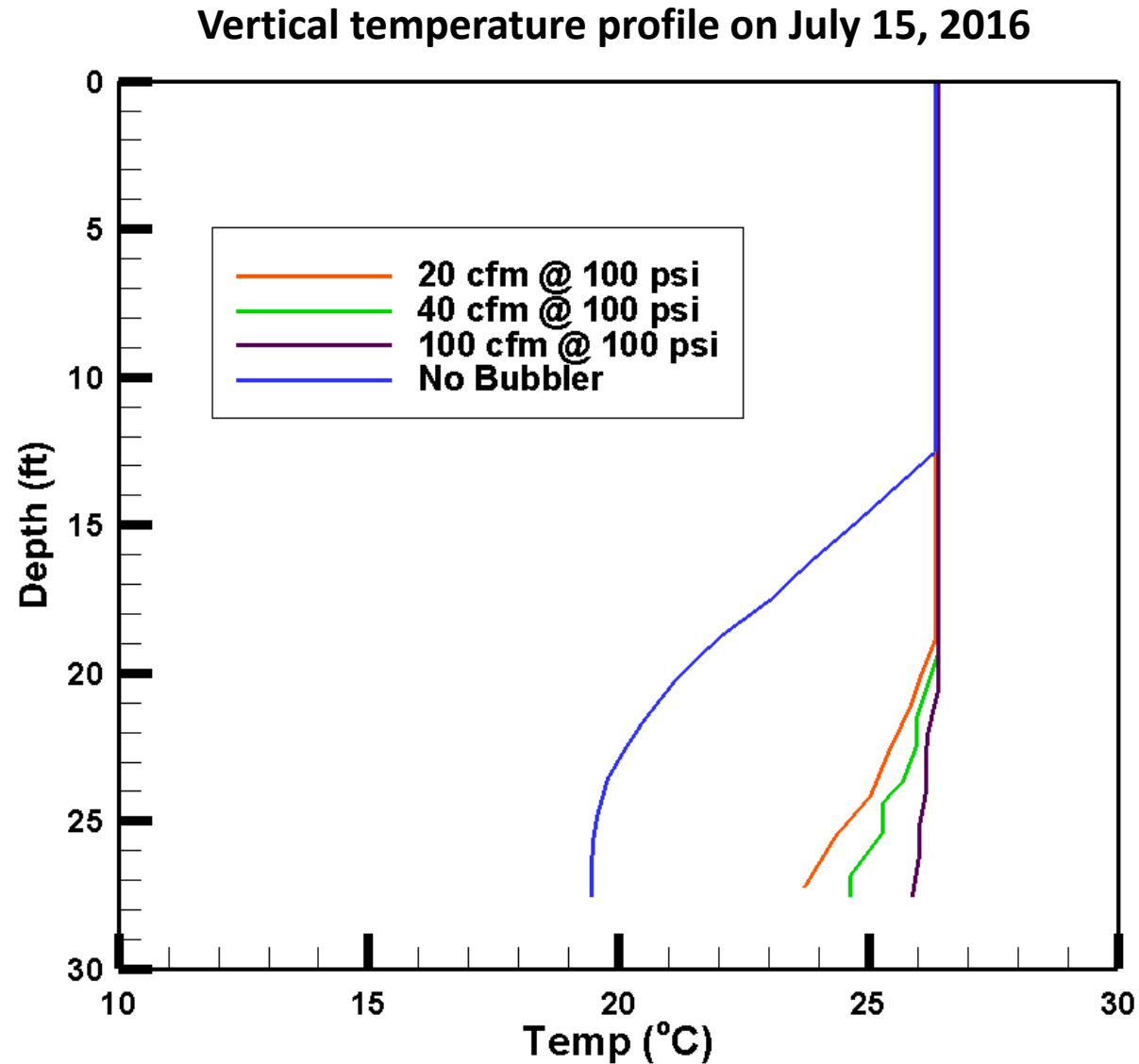
100 cfm @ 100 psi (680 scfm)
25,000 ac-ft

Beginning of aerator operation



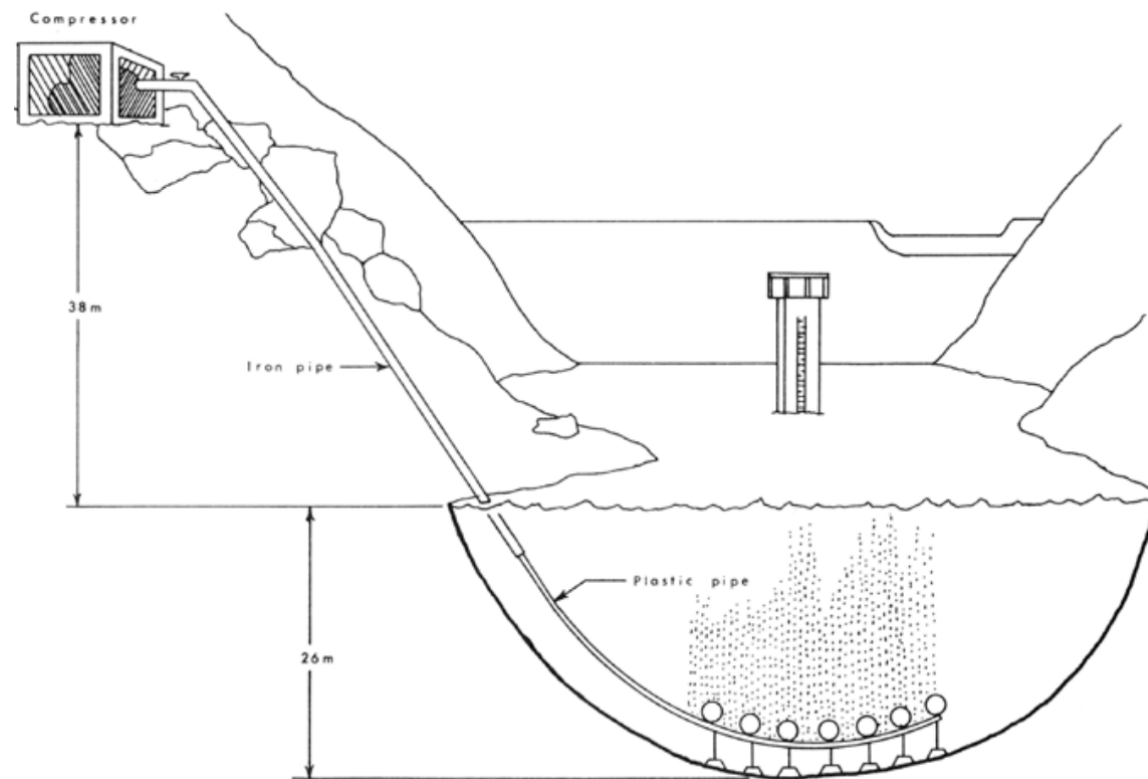
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Destratification Modeling: Storage = 5,000 a-f



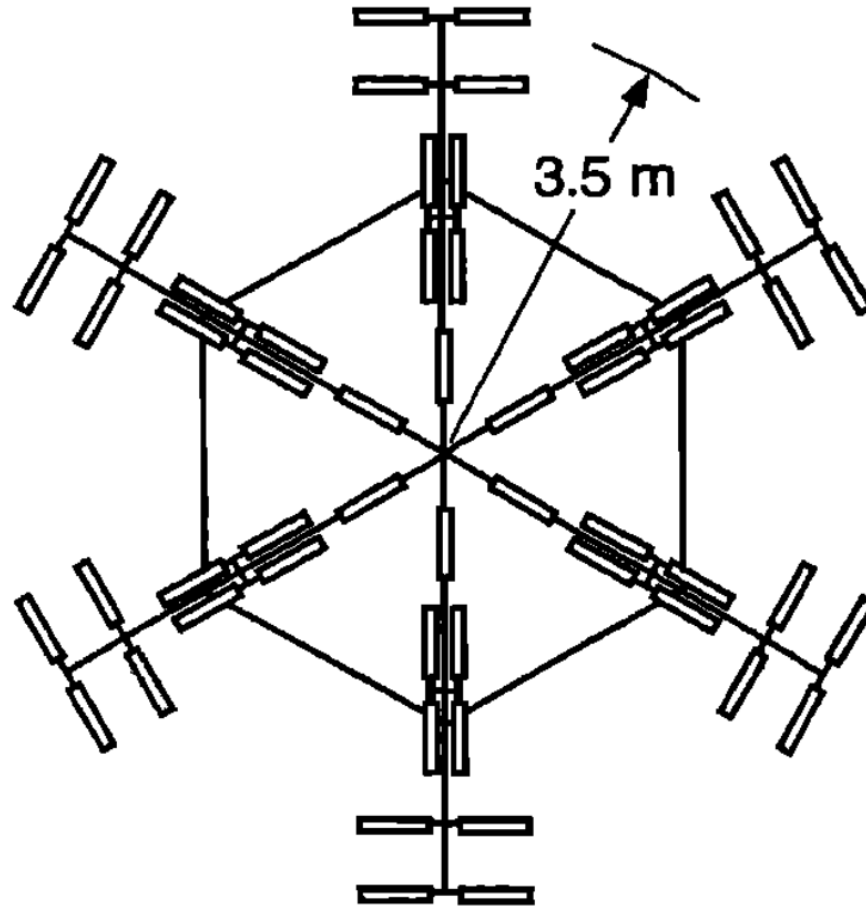
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Linear Diffuser



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Membrane Diffuser Tubes



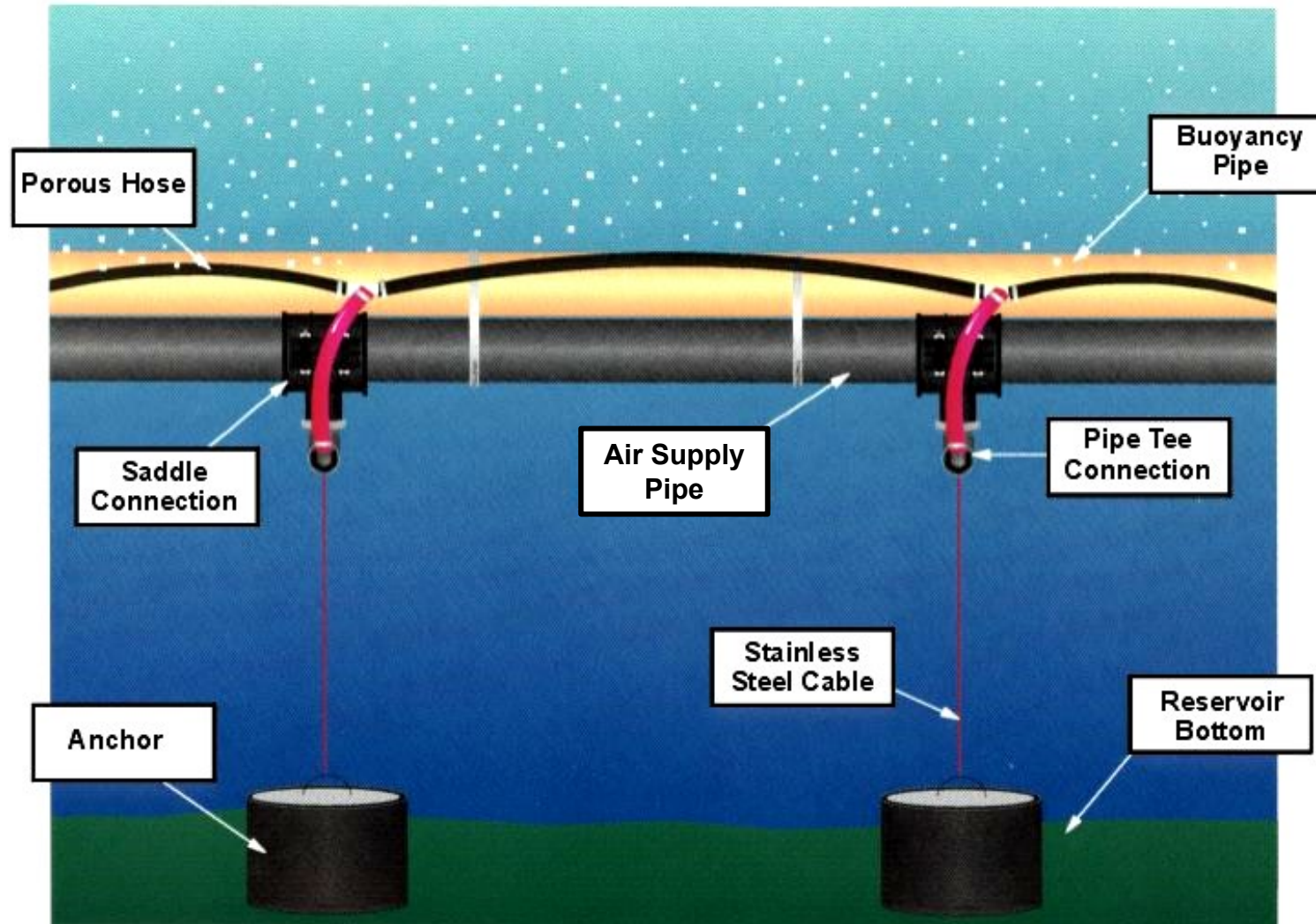
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Membrane Disc Diffuser



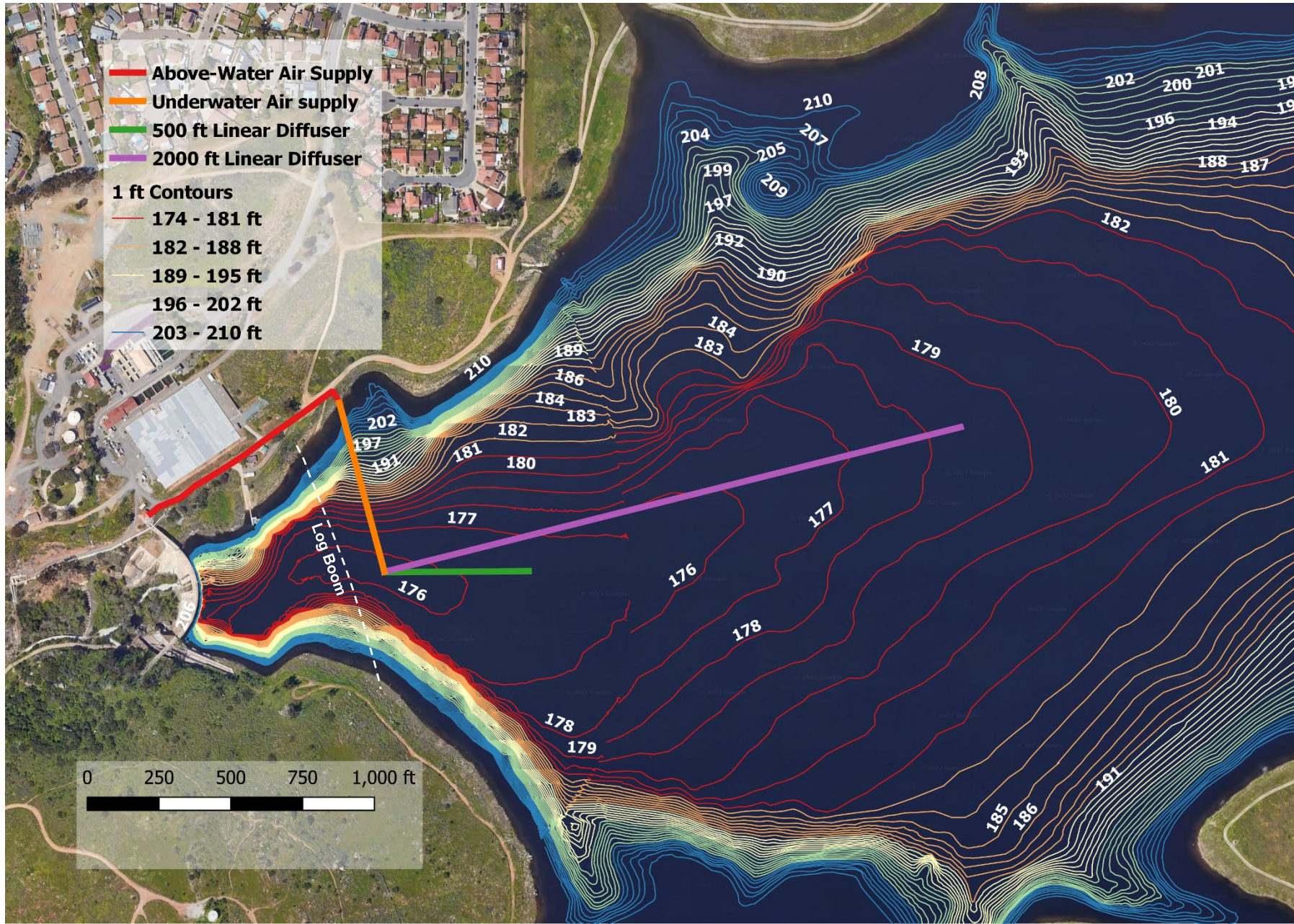
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Bubble Tube Diffuser Schematic



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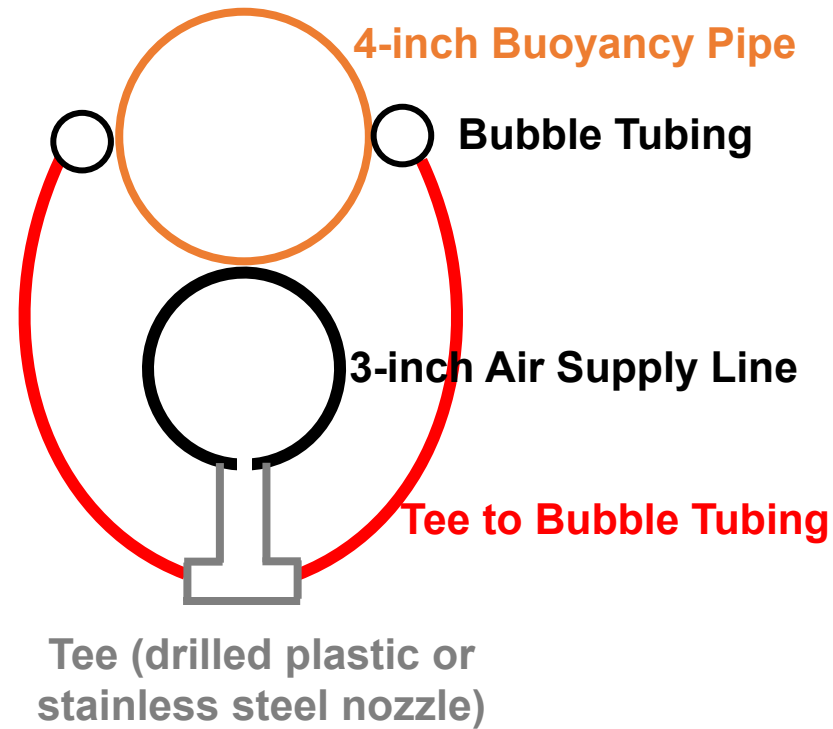
Possible Diffuser Layouts: 500 ft or 2000 ft



- 2021 contours used in western portion of reservoir near dam
- 2006 contours used in rest of reservoir

DRAFT

Bubble Tube Diffuser Port to Pipe Connection



DRAFT

Surface Visibility



C.W. Bill Young Reservoir, Tampa Bay Water (FL)
Flow Rate: 0.08 scfm/ft

DRAFT

Bubble Tube Diffuser Assembly



DRAFT

Bubble Tube Diffuser Assembly



DRAFT

Diffuser Installation



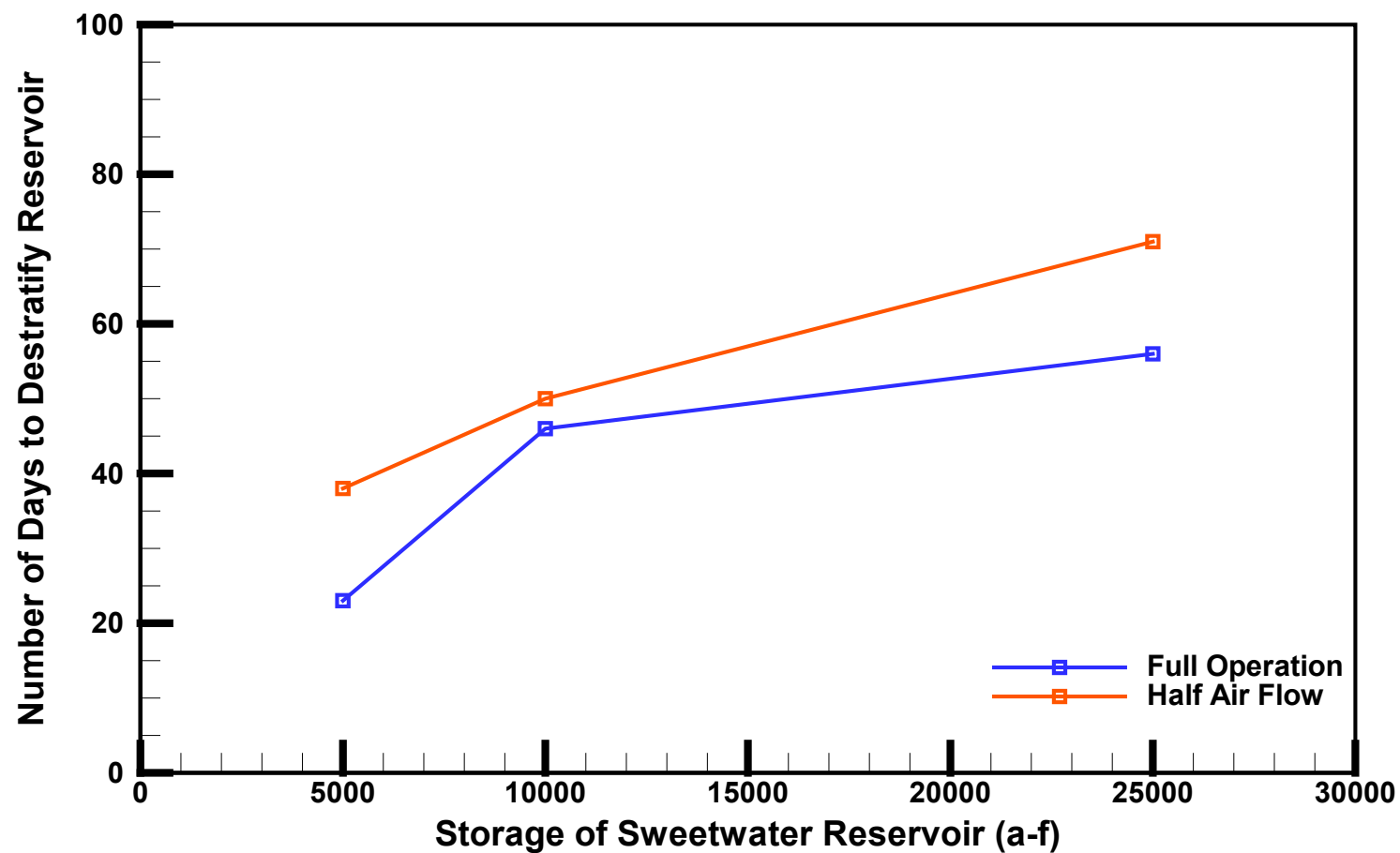
DRAFT

Diffuser Installation



DRAFT

Destratification Time*



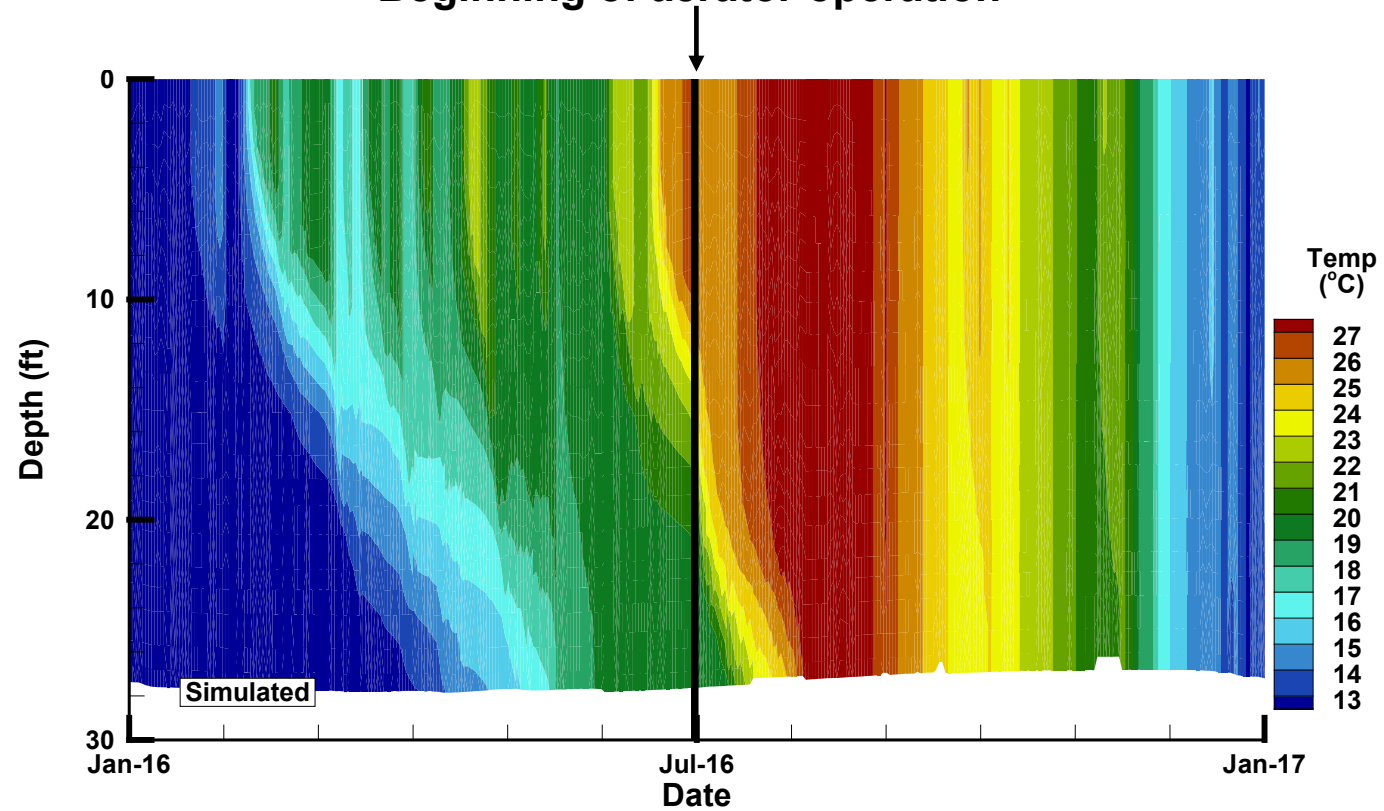
*Destratification defined as a difference in temperature between 5 ft from bottom and surface $< 2^{\circ}\text{C}$

DRAFT
For Internal Distribution Only

Destratification Modeling: Storage = 5,000 a-f, Half Air Flow

50 cfm @ 100 psi (340 scfm)
5,000 ac-ft

Beginning of aerator operation



DRAFT

For Internal Distribution Only

APPENDIX B

Selected Equipment Details

APPENDIX B

Selected Equipment Details

Oil-Flooded Compressor System



*Thomas Nolan &
Hazen and Sawyer*

Quote Reference # CTS-60551

Quote Valid until 05/18/2022

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PROPOSAL

Quote Reference# CTS-60551

Quote Prepared on 04/15/2022 | Valid until 05/18/2022

Thomas Nolan

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US
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Nathan Lamb

Ingersoll-Rand Industrial US Inc
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United States
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Ph: (657) 255-0069



*Your Trusted Partner in
Compressed Air*

RS55I-A125, 460V, PORO, HD INLET, MODULATION W/HELIX

Ingersoll Rand works to keep you ahead of your competition with Next Generation R-Series air compressors that lower total cost of ownership through high-quality components, industry-leading energy efficiency and global expertise.

- Improved Efficiency and Air Flow: Airend features optimized rotor profile that delivers up to 16% improved efficiency and 21% greater airflow capacity
- Remote Intelligent Control: Xe-Series controller delivers increased control functionality through an intuitive user interface and remote access with any common, current web browser
- Leak-free Design: V-Shield Technology provides a totally integrated, leak-free design featuring PTFE stainless steel braided oil hoses and O-ring face seals
- Reduced Downtime: Progressive Adaptive Control (PAC™) monitors key operating parameters and continuously adapts to prevent unexpected downtime
- Decrease Energy Use: NEMA Premium® efficiency motor delivers significant energy savings, and the optional variable speed drive (VSD) further decreases energy demand



Representative image may not represent quoted product configuration.

Technical Information

Max. Pressure		Nominal Power		Capacity (FAD)*		Dimensions (Length x Width x Height)		Weight (Air-cooled)	
bar g	psig	kW	hp	m3 / min	cfm	mm	in	kg	lb
8	115	55	75	10	360	2433 mm, 1250 mm, 2032 mm	95.79 in, 49.21 in, 80.0 in	1841	4050.2

NVC 800 460-3-60 Air-Cooled NEMA 4 with Timed Solenoid Drain

Nirvana cycling refrigerated dryers are best in class design uses centrifugal separation to remove moisture from the chilled air, resulting in highly efficient moisture removal and exceptionally dry, clean air under all operating conditions.

- Operates only when required by load demand reducing energy use
- Centrifugal separation pulls unwanted moisture from the air and removes it through a reliable float-type or timed electric solenoid drain
- Thermal mass with submerged evaporator is fully insulated to maintain a cold well of propylene glycol-water to provide continuous ISO Class 4 quality air with 38°F dew point
- Automatic controls reduce energy draw by shutting down the refrigerated compressor as quickly as possible, while maintaining continuous performance
- 5 Year Extended Warranty available covering all major components with Parts or PlannedCare Agreement and the purchase of Ingersoll Rand pre- & post-filters



Representative image may not represent quoted product configuration.

Technical Information

Max. Pressure		Nominal Power		Capacity (FAD)*		Dimensions (Length x Width x Height)		Weight (Air-cooled)	
bar g	psig	kW	hp	m3 / min	cfm	mm	in	kg	lb
		6.7	8.9848	22.65	800	1016 mm, 1067 mm, 1575 mm	40.0 in, 42.01 in, 62.01 in	642	1412.4

FA1560IG GENERAL PURPOSE FILTER, 3" NPT, 920 SCFM, W/AUTODRAIN

F-Series advanced compressed air filters reduce contamination in your air stream to help protect critical processes and valuable equipment. Rigorously tested and engineered with superior components, F-Series filters will provide years of reliable performance and consistently high quality air.

- **Accurate Information:** Patented dual indicator shows differential pressure drop and operating efficiency
- **Rugged Design:** All-aluminum, precision die cast body suitable for 176 °F / 80 °C and 250 psig / 17.2 bar MAWP applications
- **Reliable Operation:** Filter element with stainless steel mesh withstands high pressure and minimizes flow restriction
- **Easy Maintenance:** Ergonomic bowl design with no-touch filter simplifies element replacement
- **Long Element Life:** Proprietary media coating technology protects against corrosion and increases element life



Representative image may not represent quoted product configuration.

Technical Information

Max. Pressure		Nominal Power		Capacity (FAD)*		Dimensions (Length x Width x Height)		Weight (Air-cooled)	
bar g	psig	kW	hp	m3 / min	cfm	mm	in	kg	lb
17	250	N/A	N/A	26.0515	920	765 mm, 206 mm, 181 mm	30.12 in, 8.11 in, 7.13 in	10.7	23.54

FA1560IH HIGH EFFICIENCY FILTER, 3" NPT, 920 SCFM, W/AUTODRAIN

F-Series advanced compressed air filters reduce contamination in your air stream to help protect critical processes and valuable equipment. Rigorously tested and engineered with superior components, F-Series filters will provide years of reliable performance and consistently high quality air.

- **Accurate Information:** Patented dual indicator shows differential pressure drop and operating efficiency
- **Rugged Design:** All-aluminum, precision die cast body suitable for 176 °F / 80 °C and 250 psig / 17.2 bar MAWP applications
- **Reliable Operation:** Filter element with stainless steel mesh withstands high pressure and minimizes flow restriction
- **Easy Maintenance:** Ergonomic bowl design with no-touch filter simplifies element replacement
- **Long Element Life:** Proprietary media coating technology protects against corrosion and increases element life



Representative image may not represent quoted product configuration.

Technical Information									
Max. Pressure		Nominal Power		Capacity (FAD)*		Dimensions (Length x Width x Height)		Weight (Air-cooled)	
bar g	psig	kW	hp	m3 / min	cfm	mm	in	kg	lb
17	250	N/A	N/A	26.0515	920	765 mm, 206 mm, 181 mm	30.12 in, 8.11 in, 7.13 in	10.7	23.54

PolySep AS85 Oil Water Separator (850 cfm)

PolySep Oil Water Separators feature a specially coated Zeolite adsorption media that is able to withdraw and permanently adsorb virtually all lubricants. This proprietary filtration media can even handle highly emulsified lubricants like polyglycols, which are difficult to separate without the use of expensive, oversized separators as found in many competitive systems.

- Proven PolySep Zeolite Filtration Media works with all lubricants, including Ultra Coolant
- Removes virtually everything from water, including mineral oils, PAOs, polyolesters, diesters and polyglycols
- Designed to handle all condensate flow requirements up to 380 liters/hour (100 gallons/hour), even in hot and humid environments
- Zeolite adsorption media has a long life, only needing to be replaced once a year or after 4,000 hours of operation
- Complies with environmental regulations by minimizing fluid disposal costs



Representative image may not represent quoted product configuration.

Technical Information

Max. Pressure		Nominal Power		Capacity (FAD)*		Dimensions (Length x Width x Height)		Weight (Air-cooled)	
bar g	psig	kW	hp	m3 / min	cfm	mm	in	kg	lb
N/A	N/A	N/A	N/A	24.0693	850	736.6 mm, 508 mm, 965.2 mm	29.0 in, 20.0 in, 38.0 in	141	310.2

RECEIVER, HORZ 1060 GAL / 150 PSI, STANDARD PRIMER

Our air compressor tanks, available in horizontal & vertical, are designed for extra air storage & made with steel for long-lasting durability.

- Horizontal & Vertical Tanks
- Sizes (12-20, 500 gallon / 125-250 psig)
- Topplate & Mounting Options
- Internal and External Coatings



Representative image may not represent quoted product configuration.

Technical Information									
Max. Pressure		Nominal Power		Capacity (FAD)*		Dimensions (Length x Width x Height)		Weight (Air-cooled)	
bar g	psig	kW	hp	m3 / min	cfm	mm	in	kg	lb
							144.0 in		2320

START UP SERVICE

Service Details

Scope of Service	Included
Commissioning performed by factory trained and certified technicians	Yes
Confirm proper installation per operator's manual	Yes
Check operating temperatures, pressures, amperage and other key parameters per Ingersoll Rand 47-point checklist	Yes
Check rotation of 3 phase motors	Yes
Adjust and set control set points and key operating parameters	Yes
Basic operator training 30 min	Yes
How to get service help if needed	Yes
Maintenance schedule review	Yes
Install review & validation	Yes

Investment Summary for Hazen and Sawyer (04-15-2022)

Line #	Product Description	Qty	Unit Price	Extended Price
1.0	RS55I-A125, 460V, PORO, HD INLET, MODULATION W/HELIX	2	\$34,774.75	\$69,549.50
2.0	NVC 800 460-3-60 Air-Cooled NEMA 4 with Timed Solenoid Drain	1	\$17,943.98	\$17,943.98
3.0	FA1560IG GENERAL PURPOSE FILTER, 3" NPT, 920 SCFM, W/AUTODRAIN	1	\$2,207.00	\$2,207.00
4.0	FA1560IH HIGH EFFICIENCY FILTER, 3" NPT, 920 SCFM, W/AUTODRAIN	1	\$2,207.00	\$2,207.00
5.0	PolySep AS85 Oil Water Separator (850 cfm)	1	\$5,987.00	\$5,987.00
6.0	RECEIVER,HORZ 1060GAL/150PSI, STANDARD PRIMER	1	\$11,904.00	\$11,904.00
7.0	EDV-2000 Electronic Drain Valve Kit (978 SCFM, 150 PSI, 1.0" NPT Relief Valve Inlet)	1	\$691.00	\$691.00

Line #	Product Description	# of Days	Standard Hours	Overtime Hours	Extended Overtime Hours	Total Service Fee
8.0	START UP SERVICE					\$2,040.00
	Included Component					
8.1	Start Up-Large Rotary					

Product/Service Quote Amount	\$112,529.48
Upgrade Option(s) Amount	--
Freight Amount	PPA
Total Quote Amount	\$112,529.48

General Terms

Lead Time:	Estimated 50 Day Lead Time - Subject to Change	Pricing and availability is subject to change without notice. Upon submission of your order, please include the following information: payment terms, preferred payment method, purchase order number, tax status (if exempt please include a copy of your tax exemption certificate with your order).
Payment Terms:		
FOB:	EX WORKS	For US, please remit all payments to Ingersoll Rand, 15768 Collections Center Drive, Chicago, IL, 60693. For Canada, please remit all payments to IR Canada Sales & Service ULC, C/O T10223C PO Box 4918 STN A, Toronto, ONTARIO M5W 0C9, Canada. Also, please be aware that Ingersoll Rand accepts payment via credit card, and EFT.
Freight Terms:	Prepay & Add	

Progress Payments apply to orders exceeding \$100,000 USD. Standard progress payment terms are 30% at order acceptance, 30% at Eight (8) weeks after purchase order, and 40% upon shipment.

Purchase Order Acknowledgement

Date: 04/15/2022

SHIP TO SITE INFORMATION		BILLING INFORMATION	
Company Name:	Hazen and Sawyer	Company Name:	
Business Address:	7870 East Kemper Road Suite 300	Business Address:	
City, ST, Zip:	CINCINNATI, OH, 45249	City, ST, Zip:	, ,
Site Contact:	Thomas Nolan	Business Phone:	5134692751
Business Phone:	5134692751	Business E-mail:	tnolan@hazenandsawyer.com
Business E-mail:	tnolan@hazenandsawyer.com	Payment Terms:	
PO Number:			
Siebel Order #:		Progress Payments (if required):	(IR Standard Milestone Payments)
Oracle Order #:		30% at order acceptance	
	(For office use only)	30% at Eight Weeks After PO	
		40% on Shipment	

Thank you for your order. In an effort to process your order as quickly as possible please review the Shipping & Billing information noted above, and the scope of supply shown below, to verify the information is correct.

Priority: _____

Shipping Method: STANDARD-TRUCK

FOB Point: EX WORKS

Freight Terms: Prepay & Add

Shipping Instructions: _____

The sale of our equipment is governed solely by the Standard Terms & Conditions of Sale 3.17 and Form 3814; copies of which are attached hereto. Notwithstanding any objection in advance, we will proceed on the basis that such terms and conditions will govern this transaction, excluding any revised, additional, or conflicting terms and conditions submitted with your purchase order form.

Authorized Signature: _____ Date: _____

Printed Name: _____ PO Number: _____

Company/Title: _____

Please send completed form to:

IR Rep: Nathan Lamb

Phone: (657) 255-0069

Email: nathan.lamb@irco.com

Nathan Lamb
(657) 255-0069
nathan.lamb@irco.com

Hazen and Sawyer
Quote Reference
#CTS-60551

SCOPE OF SUPPLY WORKSHEET

Line Number	Quantity	Part Number	Description	Unit Price	Extended Price
1.0	2	47764058001	RS55I-A125, 460V, PORO, HD INLET, MODULATION W/HELIX	\$34,774.75	\$69,549.50
2.0	1	23577067	NVC 800 460-3-60 Air- Cooled NEMA 4 with Timed Solenoid Drain	\$17,943.98	\$17,943.98
3.0	1	24234254	FA1560IG GENERAL PURPOSE FILTER, 3" NPT, 920 SCFM, W/AUTODRAIN	\$2,207.00	\$2,207.00
4.0	1	24234270	FA1560IH HIGH EFFICIENCY FILTER, 3" NPT, 920 SCFM, W/AUTODRAIN	\$2,207.00	\$2,207.00
5.0	1	17933053	PolySep AS85 Oil Water Separator (850 cfm)	\$5,987.00	\$5,987.00
6.0	1	38017281	RECEIVER, HORZ 1060GAL/ 150PSI, STANDARD PRIMER	\$11,904.00	\$11,904.00
7.0	1	38002960	EDV-2000 Electronic Drain Valve Kit (978 SCFM, 150 PSI, 1.0" NPT Relief Valve Inlet)	\$691.00	\$691.00
8.0	1	START UP SERVICE		\$2,040.00	\$2,040.00
				Subtotal: Scope of Supply	\$112,529.48
				ORDER TOTAL	\$112,529.48

Additional Order Comments:

STANDARD TERMS AND CONDITIONS OF SALE INDUSTRIAL TECHNOLOGIES AND SERVICES

1. **General** Any written or oral order received from Buyer by Ingersoll-Rand Industrial, U.S., Inc., ("Company") is governed by the Standard Terms and Conditions of Sale outlined herein ("Terms"). COMPANY'S ACCEPTANCE OF BUYER'S ORDER IS EXPRESSLY CONDITIONED ON BUYER'S ACCEPTANCE OF THESE TERMS. Company rejects any terms and conditions inconsistent with these Terms and to any other terms proposed by Buyer in accepting Company's proposal. No agreement, oral or written, in any way claiming to modify these Terms and Conditions will be binding on Company unless agreed to in writing by an authorized representative of Company.
2. **Taxes** Prices do not include any present or future Federal, State, or local property, license, privilege, sales, use, excise, gross receipts or other like taxes or assessments applicable to this order ("Taxes"). All Taxes will be itemized separately. Buyer will be responsible for the payment of any Taxes to Company unless Buyer provides a valid exemption certificate. If the exemption certificate is not recognized by the governmental taxing authority, Buyer will reimburse Company for any Taxes, including any interest or penalty assessed against Company.
3. **Title and Risk of Loss** Title and risk of loss or damage to equipment will pass to Buyer upon tender of delivery FOB Company facility, except that Buyer grants Company a lien on and a purchase money security interest in and to all of the right, title, and interest of Buyer in the equipment purchased hereunder until full payment has been made.
4. **Credit Terms**
 - a. **Payment.** Buyer shall pay the amounts due and owing to Company identified on each invoice in full and in accordance with the terms specified on each invoice.
 - b. **Invoice Disputes.** Buyer shall notify Company in writing of any dispute with any invoice (along with substantiating documentation) prior to the invoice due date. Invoices for which no such timely notification is received shall be deemed accepted by Buyer as true and correct. The parties shall seek to resolve all such disputes expeditiously and in good faith. Should any dispute arise with respect to any goods delivered by Company to Buyer, Buyer shall nevertheless pay all invoices covering goods not in dispute, without setoff, defense or counter-claim.
 - c. **Late Payments.** On any invoice not paid when due, Buyer shall pay a late charge from the due date to the date of actual payment at the lesser of the simple interest rate of 12% per annum calculated monthly or the highest rate permissible under applicable law. Buyer shall reimburse Company for all costs incurred in collecting any late payments, including, without limitation, attorneys' fees. In addition to all other remedies available under these Terms and Conditions or at law (which Company does not waive by the exercise of any rights hereunder), Company shall be entitled to suspend the delivery of any goods if Buyer fails to pay any amounts when due.
 - d. **Acceleration.** Should Buyer fail to make any payment required hereunder, Company may, without notice, declare all obligations of Buyer to Company ("Obligations") immediately due and payable, whether or not such late charges are included in any statement of account rendered by Company to Buyer.
 - e. **No Partial Payments.** Buyer irrevocably agrees that it will not, without Company's prior written consent in each instance, tender any payments for less than the full amount of the invoices to which said payment applies ("Partial Payments"). Any Partial Payments tendered by or for the account of Buyer shall not extinguish or otherwise affect any unpaid portion of the subject invoices, despite any notation on or accompanying said payment such as "in full payment," "in full satisfaction," or words of similar effect.
 - f. **Sufficient Funds.** Buyer represents that all checks issued to Company will be honored by the drawee bank, and that no checks will be so issued unless Buyer then has funds on deposit in an amount sufficient to cover all checks issued by Buyer. Buyer acknowledges that this representation will be materially relied upon by Company in extending credit to Buyer.
 - g. **Right to Set Off.** Any payment received by Company from Buyer may be applied by Company against any obligation owing by Buyer to Company, regardless of any statement appearing on or referring to such payment, without discharging Buyer's liability for any additional amounts owing by Buyer to Company. The acceptance by Company of such payment shall not constitute a waiver of Company's right to pursue any remaining balance. With respect to any monetary obligations of Company to Buyer, including without limitation, volume rebates and advertising rebates, Company may, at any time, setoff and appropriate and apply such amounts against any sums that are, or will become, owing, due or payable to Company by Buyer under these Terms and Conditions or any other agreement.
5. **Financial Condition of Buyer**
 - a. **Receipt of Goods While Insolvent** In the event that Buyer receives any goods from Company while Buyer is insolvent (as such term is used in §2- 702 of the Uniform Commercial Code, United-States of America), this writing and the invoices received from Company relating to such goods shall constitute Company's demand for reclamation of such goods.
 - b. **Withdraw of Credit Approval** Company reserves the right before shipment of any goods ordered by Buyer from Company, to require that all or a portion of the purchase price relating thereto be paid to Company, in good funds, prior to shipment.
 - c. **Material Adverse Change in Financial Condition** Notwithstanding the stated due date of any obligations, all Obligations shall become immediately due and payable, without notice, in the event that Company determines there to have been a material adverse change in the financial condition or business affairs of Buyer so that in Company's reasonable judgment Buyer's ability to pay the Obligations has become impaired.
 - d. **Verification of Credit References.** Company is authorized to contact any credit references provided by Buyer, and to disclose any information reasonably necessary to determine Buyer's credit worthiness. Company is also authorized to obtain personal credit reports on any partner, principal, officer, or potential guarantor in determining Buyer's creditworthiness. Company may also disclose any information concerning its relationship with Buyer which is requested by anyone identifying themselves as an existing or potential creditor of Buyer.
 - e. **Disclosure of Buyer's Right to a Statement of Reasons for Action.** If this application is not approved in full or if any other adverse action is taken with respect to Buyer's credit, Buyer has the right to request within 60 days of Company's notification of such adverse action, a statement of specific reasons for such action, which statement will be provided within 30 days of said request.
6. **Delivery** Company will deliver goods within a reasonable time after receipt of Buyer's order and in no event will delivery dates be construed as falling within the meaning of "time is of the essence."
7. **Force Majeure** Company will not be liable for any loss or damage due to delays arising from causes beyond the reasonable control of Company, including but not limited to any acts of God, fire, flood, earthquake or explosion, strikes or other labor difficulties, wars, riots, terrorist threats, national emergencies, or acts of governments. In such events, Company will have additional time within which to deliver or perform as may be reasonably necessary under the circumstances. If Buyer requires drawings, procedures, standards or similar material for approval, delivery schedules will be calculated from the time such approvals are received by Company. Any hold points, witness points, or Buyer inspection requirements must be identified by Buyer at the time of quotation and/or order placement. Additional inspection or testing required by Buyer will extend delivery dates accordingly.
8. **Storage Fee** If Buyer is not able to accept delivery on the date agreed to by the parties, Buyer will pay Company a storage fee equivalent to one and one half percent (1.5%) of the total order value per calendar month or fraction thereof (calculated and charged on a per day basis) until the date of delivery ("Storage Fee"). Additionally, if Company is performing installation services and at the time of delivery Buyer's location is not ready or is unsafe for installation, Company reserves the right to postpone or to discontinue work. In such event, Company may charge Buyer an amount equivalent to the Storage Fee until such time that the location is ready and safe for installation, as determined by Company.
9. **Warranty** Company warrants, to purchasers from a Company authorized seller (each a "Buyer"), that the equipment manufactured by it and services provided by it will be free from defects in material and workmanship, for the duration of the specified Warranty Period. For new equipment, a period of twelve (12) months from the date of initial operation not to exceed eighteen (18) months from shipment, whichever first occurs, except for the Airend of new oil-flooded rotary screw air compressors, which is for the duration as detailed in the 5 Year Airend Parts Warranty below; for parts and services, six (6) months from the date of shipment; for services, six (6) months from the date of installation, inclusive of transportation and installation costs if installed by Company or six (6) months from the date of delivery exclusive of transportation and installation costs if not installed by Company (each a "Warranty Period"). Equipment or parts manufactured by others are warranted only to the extent of the original manufacturer's warranty to Company.
5 Year Airend Parts Warranty: Company Warrants , to a Buyer, that the Airend, as defined below, of new oil-flooded rotary screw air compressors manufactured by Company, will be free from defects in material and workmanship for a period of five (5) years from the date of initial operation not to exceed sixty-six (66) months from shipment, whichever occurs first.

10. **Order Cancellation** If Buyer cancels an order, Buyer will pay a cancellation fee to Company in an amount equal to Company's direct out of pocket costs incurred plus a percentage of the order value to cover sales and administrative expenses. The percentage is based on the proportion of time which has elapsed from the date the order is placed to the originally scheduled shipment date as follows:

Percent of time elapsed from PO date to scheduled ship date	Cancellation fee % of PO Value
0-10%	5%
11-20%	15%
21-30%	25%
31-40%	35%
41-50%	45%
51-60%	55%
61-70%	65%
71-80%	75%
81-90%	85%
91-100%	95%

11. **Compliance with Laws** Company will comply with all applicable laws and regulations in effect in the location of manufacture on the date an order is placed. Compliance with any local governmental laws or regulations relating to location, use, or operation of the equipment, or its use in conjunction with other equipment, will be the sole responsibility of Buyer. Equipment purchased hereunder is produced in accordance with all applicable requirements of Section 6, 7, and 12 of the Fair Labor Standards Act as amended and of regulations and orders of the United States Department of Labor issued under Section 14 thereof. Where applicable, the Federal Equal Credit Opportunity Act prohibits creditors from discrimination against credit applicants on the basis of race, color, religion, national origin, sex, marital status, or age (provided that the applicant has the capacity to enter into a binding contract); because of all or part of the applicant's income derives from any public assistance programs; or because the applicant has in good faith exercised any right under the Consumer Protection Act. The federal agency that administers compliance with this law concerning the creditor is the Federal Trade Commission, Washington, D.C.
12. **Data Privacy** Buyer understands and agrees that certain of the Products include technology that allows Company to collect technical and product-related information regarding such Products and to conduct remote diagnostics testing of such Products. This technology allows Company to better serve and assist Buyer in the event such Products need to be repaired, and to maintain and improve the Products. Buyer agrees to grant and hereby grants Company a transferable, sub-licensable, non-exclusive, non-revocable, worldwide right to access and use the data collected and processed by the technology for Company's business purposes, including analysis, research, and development. In addition, Company may share such information with its affiliates, subsidiaries, and service providers; and with third parties but only in an aggregate, de-identified format, with third parties for research, statistical and business purposes unless otherwise agreed to or in accordance with the applicable privacy policy. To the extent that Company receives any individually identifiable personal information regarding Buyer from such technology, Company's policy is to protect the confidentiality of such information, and to prohibit the unlawful disclosure of Buyer's personal information to third parties. Company will take reasonable steps to insure the safety of Buyer's personal information.
13. **Export Control** Buyer agrees not to disclose or export, either directly or indirectly, any Company technology or information, or the direct product thereof, to any destination or person if such disclosure or export is prohibited by U.S. laws and regulations. In particular, Buyer will not use and will not permit any third party to use Company technology or information in connection with the design, production, use or storage of chemical, biological or nuclear weapons or missiles of any kind. This paragraph will survive the termination of this contract.
14. **Patent Indemnity** Company will defend Buyer against any proceeding based upon a claim that the equipment manufactured by Company infringes any U.S. patent, provided that Company is promptly notified in writing and given authority, information, and assistance for defense of the same. If any claim materially interferes with Buyer's use of the equipment, Company will, at its option, procure for Buyer the right to continue to use such equipment, modify it so that it becomes non-infringing, replace it with non-infringing equipment, or will remove the equipment and refund the purchase price. Company does not accept any liability whatsoever in respect to patents claiming more than the equipment furnished hereunder or claiming methods or processes to be carried out with the aid of such equipment. The foregoing states the entire liability of Company with regard to patent infringement.
15. **Limitation of Liability** THE REMEDIES OF BUYER SET FORTH HEREIN ARE EXCLUSIVE, AND THE TOTAL LIABILITY OF COMPANY WITH RESPECT TO THIS CONTRACT, WHETHER BASED ON CONTRACT, WARRANTY, NEGLIGENCE, INDEMNITY, STRICT LIABILITY OR OTHERWISE, WILL NOT EXCEED THE PURCHASE PRICE FOR THE EQUIPMENT, PART OR SERVICE THAT IS THE BASIS FOR THE CLAIM. IN NO EVENT WILL COMPANY BE LIABLE TO BUYER, ANY SUCCESSORS IN INTEREST, OR ANY BENEFICIARY OR ASSIGNEE OF THIS CONTRACT FOR ANY CONSEQUENTIAL, INCIDENTAL, INDIRECT, SPECIAL, OR PUNITIVE DAMAGES, OR LOST PROFITS OR REVENUE ARISING OUT OF THIS CONTRACT OR ANY BREACH THEREOF, OR ANY DEFECT IN, OR FAILURE OF, OR MALFUNCTION OF THE EQUIPMENT, PART OR SERVICE HEREUNDER, WHETHER OR NOT SUCH LOSS OR DAMAGE IS BASED ON CONTRACT, WARRANTY, NEGLIGENCE, INDEMNITY, STRICT LIABILITY, OR OTHERWISE.
16. **Assignment** Buyer will not assign or transfer this contract without the prior written consent of Company, and such consent will not be unreasonably withheld. Additionally, Buyer will not sell all or a substantial portion of its assets to another entity (the "Successor") without the prior written consent of Company. In the event that Buyer does not provide such notice to Company and the business previously conducted by Buyer is or may be continued by the Successor, Buyer shall be liable for and shall pay on demand the amount of all accounts receivable due by Successor to Company arising from the date of such sale of assets to the date Company learns of such asset sale.
17. **No Waiver** No waiver by Company of any of the provisions of this Contract is effective unless explicitly set forth in writing and signed by Company. No failure to exercise, partial exercise, or delay in exercising, any right, remedy, power or privilege arising from this Contract operates, or may be construed, as a waiver thereof.
18. **Governing Law** The rights and obligations of the parties will be governed by the laws of the State of North Carolina excluding any conflict of law provisions. The United Nations Convention on Contracts for the International Sale of Goods will not apply to this contract.
19. **No Reference Required** Buyer and Company agree that each order shall constitute a separate contract, the performance of which will be governed exclusively by these Terms. This Agreement shall govern an order regardless of whether or not this document is attached to or referenced in the order. Excluded from applicability to an order include, but are not limited to: (i) any other terms and conditions contained in the order, including terms contained on the reverse side of the order; (ii) any reference in an order to Buyer's Internet site for terms and conditions; (iii) any reference in an order to any other agreement, document or terms unless agreed to in writing by the Parties. In the event of a conflict between any terms and conditions of an order (except (iii) above), Terms shall prevail and govern the order.

APPENDIX B

Selected Equipment Details

Oil-Free Compressor System



*Thomas Nolan &
Hazen and Sawyer*

Quote Reference # CTS-59311

Quote Valid until 05/18/2022

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PROPOSAL

Quote Reference# CTS-59311

Quote Prepared on 04/06/2022 | Valid until 05/18/2022

Thomas Nolan

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Ph: (657) 255-0069



*Your Trusted Partner in
Compressed Air*

Sierra L75 100 PSI (75 HP) Oil Free Rotary Screw Compressor

Delivering reliable oil-free compressed air to your facility goes well beyond the compressor itself. Optimize total cost of ownership through a systems approach that employs the best air compression technologies to deliver reliability for life.

- Robust Components
- Efficient Design
- Simple and Serviceable
- Advanced Compressor Control
- UltraCoat—Energy Savings and Longer Life



Representative image may not represent quoted product configuration.

Technical Information

Max. Pressure		Nominal Power		Capacity (FAD)*		Dimensions (Length x Width x Height)		Weight (Air-cooled)	
bar g	psig	kW	hp	m3 / min	cfm	mm	in	kg	lb
7.1	102.95	55	75	9.5	336	2248 mm, 1372 mm, 1914 mm	88.5 in, 54.02 in, 75.35 in	2433	5352.6

NVC 700 460-3-60 Air-Cooled NEMA 4 with Timed Solenoid Drain

Nirvana cycling refrigerated dryers are best in class design uses centrifugal separation to remove moisture from the chilled air, resulting in highly efficient moisture removal and exceptionally dry, clean air under all operating conditions.

- Operates only when required by load demand reducing energy use
- Centrifugal separation pulls unwanted moisture from the air and removes it through a reliable float-type or timed electric solenoid drain
- Thermal mass with submerged evaporator is fully insulated to maintain a cold well of propylene glycol-water to provide continuous ISO Class 4 quality air with 38°F dew point
- Automatic controls reduce energy draw by shutting down the refrigerated compressor as quickly as possible, while maintaining continuous performance
- 5 Year Extended Warranty available covering all major components with Parts or PlannedCare Agreement and the purchase of Ingersoll Rand pre- & post-filters



Representative image may not represent quoted product configuration.

Technical Information

Max. Pressure		Nominal Power		Capacity (FAD)*		Dimensions (Length x Width x Height)		Weight (Air-cooled)	
bar g	psig	kW	hp	m3 / min	cfm	mm	in	kg	lb
		6.1	8.1802	19.8	700	1016 mm, 1067 mm, 1575 mm	40.0 in, 42.01 in, 62.01 in	600	1320.0

FA1200IG GENERAL PURPOSE FILTER, 3" NPT, 710 SCFM, W/AUTODRAIN

F-Series advanced compressed air filters reduce contamination in your air stream to help protect critical processes and valuable equipment. Rigorously tested and engineered with superior components, F-Series filters will provide years of reliable performance and consistently high quality air.

- **Accurate Information:** Patented dual indicator shows differential pressure drop and operating efficiency
- **Rugged Design:** All-aluminum, precision die cast body suitable for 176 °F / 80 °C and 250 psig / 17.2 bar MAWP applications
- **Reliable Operation:** Filter element with stainless steel mesh withstands high pressure and minimizes flow restriction
- **Easy Maintenance:** Ergonomic bowl design with no-touch filter simplifies element replacement
- **Long Element Life:** Proprietary media coating technology protects against corrosion and increases element life



Representative image may not represent quoted product configuration.

Technical Information

Max. Pressure		Nominal Power		Capacity (FAD)*		Dimensions (Length x Width x Height)		Weight (Air-cooled)	
bar g	psig	kW	hp	m3 / min	cfm	mm	in	kg	lb
17	250	N/A	N/A	20.105	710	665 mm, 206 mm, 181 mm	26.18 in, 8.11 in, 7.13 in	9.3	20.46

FA1200IH HIGH EFFICIENCY FILTER, 3" NPT, 710 SCFM, W/AUTODRAIN

F-Series advanced compressed air filters reduce contamination in your air stream to help protect critical processes and valuable equipment. Rigorously tested and engineered with superior components, F-Series filters will provide years of reliable performance and consistently high quality air.

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- **Rugged Design:** All-aluminum, precision die cast body suitable for 176 °F / 80 °C and 250 psig / 17.2 bar MAWP applications
- **Reliable Operation:** Filter element with stainless steel mesh withstands high pressure and minimizes flow restriction
- **Easy Maintenance:** Ergonomic bowl design with no-touch filter simplifies element replacement
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Representative image may not represent quoted product configuration.

Technical Information

Max. Pressure		Nominal Power		Capacity (FAD)*		Dimensions (Length x Width x Height)		Weight (Air-cooled)	
bar g	psig	kW	hp	m3 / min	cfm	mm	in	kg	lb
17	250	N/A	N/A	20.105	710	665 mm, 206 mm, 181 mm	26.18 in, 8.11 in, 7.13 in	9.3	20.46

RECEIVER, HORZ 1060 GAL/150 PSI, STANDARD PRIMER

Our air compressor tanks, available in horizontal & vertical, are designed for extra air storage & made with steel for long-lasting durability.

- Horizontal & Vertical Tanks
- Sizes (12-20, 500 gallon / 125-250 psig)
- Topplate & Mounting Options
- Internal and External Coatings



Representative image may not represent quoted product configuration.

Technical Information									
Max. Pressure		Nominal Power		Capacity (FAD)*		Dimensions (Length x Width x Height)		Weight (Air-cooled)	
bar g	psig	kW	hp	m3 / min	cfm	mm	in	kg	lb
							144.0 in		2320

START UP SERVICE

Service Details

Scope of Service	Included
Commissioning performed by factory trained and certified technicians	Yes
Confirm proper installation per operator's manual	Yes
Check operating temperatures, pressures, amperage and other key parameters per Ingersoll Rand 47-point checklist	Yes
Check rotation of 3 phase motors	Yes
Adjust and set control set points and key operating parameters	Yes
Basic operator training 30 min	Yes
How to get service help if needed	Yes
Maintenance schedule review	Yes
Install review & validation	Yes

Investment Summary for Hazen and Sawyer (04-06-2022)

Line #	Product Description	Qty	Unit Price	Extended Price
1.0	Sierra Oil Free Rotary Screw Air Compressor	2	\$93,393.74	\$186,787.48
	Included Component			
	Common, NL37-75KW (50-100HP), w/RMS (Mocksville)	2		
	Sierra L75 100 PSI (75 HP) Oil Free Rotary Screw Compressor	2		
	Main Driver : 75 HP Electric Motor 230-460/3/60V TEFC with Space Heater	2		
	Heat Exchanger: Aircooled	2		
	Power Outage Restart Option	2		
	CD, Operating/Parts Manual	2		
	Ultra Coolant	2		
2.0	NVC 700 460-3-60 Air-Cooled NEMA 4 with Timed Solenoid Drain	1	\$16,333.11	\$16,333.11
3.0	FA1200IG GENERAL PURPOSE FILTER, 3" NPT, 710 SCFM, W/ AUTODRAIN	1	\$1,809.00	\$1,809.00
4.0	FA1200IH HIGH EFFICIENCY FILTER, 3" NPT, 710 SCFM, W/ AUTODRAIN	1	\$1,809.00	\$1,809.00
5.0	RECEIVER,HORZ 1060GAL/150PSI, STANDARD PRIMER	1	\$11,904.00	\$11,904.00
6.0	EDV-2000 Electronic Drain Valve Kit (978 SCFM, 150 PSI, 1.0" NPT Relief Valve Inlet)	1	\$691.00	\$691.00

Line #	Product Description	# of Days	Standard Hours	Overtime Hours	Extended Overtime Hours	Total Service Fee
7.0	START UP SERVICE					\$2,400.00
	Included Component					
7.1	Start Up-Oil Free					

Product/Service Quote Amount	\$221,733.59
Upgrade Option(s) Amount	--
Freight Amount	PPA
Total Quote Amount	\$221,733.59

General Terms

Lead Time:	Estimated 50 Day Lead Time - Subject to Change	Pricing and availability is subject to change without notice. Upon submission of your order, please include the following information: payment terms, preferred payment method, purchase order number, tax status (if exempt please include a copy of your tax exemption certificate with your order).
Payment Terms:		
FOB:	EX WORKS	For US, please remit all payments to Ingersoll Rand, 15768 Collections Center Drive, Chicago, IL, 60693. For Canada, please remit all payments to IR Canada Sales & Service ULC, C/O T10223C PO Box 4918 STN A, Toronto, ONTARIO M5W 0C9, Canada. Also, please be aware that Ingersoll Rand accepts payment via credit card, and EFT.
Freight Terms:	Prepay & Add	

Progress Payments apply to orders exceeding \$100,000 USD. Standard progress payment terms are 30% at order acceptance, 30% at Eight (8) weeks after purchase order, and 40% upon shipment.

STANDARD TERMS AND CONDITIONS OF SALE INDUSTRIAL TECHNOLOGIES AND SERVICES

1. **General** Any written or oral order received from Buyer by Ingersoll-Rand Industrial, U.S., Inc., ("Company") is governed by the Standard Terms and Conditions of Sale outlined herein ("Terms"). COMPANY'S ACCEPTANCE OF BUYER'S ORDER IS EXPRESSLY CONDITIONED ON BUYER'S ACCEPTANCE OF THESE TERMS. Company rejects any terms and conditions inconsistent with these Terms and to any other terms proposed by Buyer in accepting Company's proposal. No agreement, oral or written, in any way claiming to modify these Terms and Conditions will be binding on Company unless agreed to in writing by an authorized representative of Company.
2. **Taxes** Prices do not include any present or future Federal, State, or local property, license, privilege, sales, use, excise, gross receipts or other like taxes or assessments applicable to this order ("Taxes"). All Taxes will be itemized separately. Buyer will be responsible for the payment of any Taxes to Company unless Buyer provides a valid exemption certificate. If the exemption certificate is not recognized by the governmental taxing authority, Buyer will reimburse Company for any Taxes, including any interest or penalty assessed against Company.
3. **Title and Risk of Loss** Title and risk of loss or damage to equipment will pass to Buyer upon tender of delivery FOB Company facility, except that Buyer grants Company a lien on and a purchase money security interest in and to all of the right, title, and interest of Buyer in the equipment purchased hereunder until full payment has been made.
4. **Credit Terms**
 - a. **Payment.** Buyer shall pay the amounts due and owing to Company identified on each invoice in full and in accordance with the terms specified on each invoice.
 - b. **Invoice Disputes.** Buyer shall notify Company in writing of any dispute with any invoice (along with substantiating documentation) prior to the invoice due date. Invoices for which no such timely notification is received shall be deemed accepted by Buyer as true and correct. The parties shall seek to resolve all such disputes expeditiously and in good faith. Should any dispute arise with respect to any goods delivered by Company to Buyer, Buyer shall nevertheless pay all invoices covering goods not in dispute, without setoff, defense or counter-claim.
 - c. **Late Payments.** On any invoice not paid when due, Buyer shall pay a late charge from the due date to the date of actual payment at the lesser of the simple interest rate of 12% per annum calculated monthly or the highest rate permissible under applicable law. Buyer shall reimburse Company for all costs incurred in collecting any late payments, including, without limitation, attorneys' fees. In addition to all other remedies available under these Terms and Conditions or at law (which Company does not waive by the exercise of any rights hereunder), Company shall be entitled to suspend the delivery of any goods if Buyer fails to pay any amounts when due.
 - d. **Acceleration.** Should Buyer fail to make any payment required hereunder, Company may, without notice, declare all obligations of Buyer to Company ("Obligations") immediately due and payable, whether or not such late charges are included in any statement of account rendered by Company to Buyer.
 - e. **No Partial Payments.** Buyer irrevocably agrees that it will not, without Company's prior written consent in each instance, tender any payments for less than the full amount of the invoices to which said payment applies ("Partial Payments"). Any Partial Payments tendered by or for the account of Buyer shall not extinguish or otherwise affect any unpaid portion of the subject invoices, despite any notation on or accompanying said payment such as "in full payment," "in full satisfaction," or words of similar effect.
 - f. **Sufficient Funds.** Buyer represents that all checks issued to Company will be honored by the drawee bank, and that no checks will be so issued unless Buyer then has funds on deposit in an amount sufficient to cover all checks issued by Buyer. Buyer acknowledges that this representation will be materially relied upon by Company in extending credit to Buyer.
 - g. **Right to Set Off.** Any payment received by Company from Buyer may be applied by Company against any obligation owing by Buyer to Company, regardless of any statement appearing on or referring to such payment, without discharging Buyer's liability for any additional amounts owing by Buyer to Company. The acceptance by Company of such payment shall not constitute a waiver of Company's right to pursue any remaining balance. With respect to any monetary obligations of Company to Buyer, including without limitation, volume rebates and advertising rebates, Company may, at any time, setoff and appropriate and apply such amounts against any sums that are, or will become, owing, due or payable to Company by Buyer under these Terms and Conditions or any other agreement.
5. **Financial Condition of Buyer**
 - a. **Receipt of Goods While Insolvent** In the event that Buyer receives any goods from Company while Buyer is insolvent (as such term is used in §2- 702 of the Uniform Commercial Code, United-States of America), this writing and the invoices received from Company relating to such goods shall constitute Company's demand for reclamation of such goods.
 - b. **Withdraw of Credit Approval** Company reserves the right before shipment of any goods ordered by Buyer from Company, to require that all or a portion of the purchase price relating thereto be paid to Company, in good funds, prior to shipment.
 - c. **Material Adverse Change in Financial Condition** Notwithstanding the stated due date of any obligations, all Obligations shall become immediately due and payable, without notice, in the event that Company determines there to have been a material adverse change in the financial condition or business affairs of Buyer so that in Company's reasonable judgment Buyer's ability to pay the Obligations has become impaired.
 - d. **Verification of Credit References.** Company is authorized to contact any credit references provided by Buyer, and to disclose any information reasonably necessary to determine Buyer's credit worthiness. Company is also authorized to obtain personal credit reports on any partner, principal, officer, or potential guarantor in determining Buyer's creditworthiness. Company may also disclose any information concerning its relationship with Buyer which is requested by anyone identifying themselves as an existing or potential creditor of Buyer.
 - e. **Disclosure of Buyer's Right to a Statement of Reasons for Action.** If this application is not approved in full or if any other adverse action is taken with respect to Buyer's credit, Buyer has the right to request within 60 days of Company's notification of such adverse action, a statement of specific reasons for such action, which statement will be provided within 30 days of said request.
6. **Delivery** Company will deliver goods within a reasonable time after receipt of Buyer's order and in no event will delivery dates be construed as falling within the meaning of "time is of the essence."
7. **Force Majeure** Company will not be liable for any loss or damage due to delays arising from causes beyond the reasonable control of Company, including but not limited to any acts of God, fire, flood, earthquake or explosion, strikes or other labor difficulties, wars, riots, terrorist threats, national emergencies, or acts of governments. In such events, Company will have additional time within which to deliver or perform as may be reasonably necessary under the circumstances. If Buyer requires drawings, procedures, standards or similar material for approval, delivery schedules will be calculated from the time such approvals are received by Company. Any hold points, witness points, or Buyer inspection requirements must be identified by Buyer at the time of quotation and/or order placement. Additional inspection or testing required by Buyer will extend delivery dates accordingly.
8. **Storage Fee** If Buyer is not able to accept delivery on the date agreed to by the parties, Buyer will pay Company a storage fee equivalent to one and one half percent (1.5%) of the total order value per calendar month or fraction thereof (calculated and charged on a per day basis) until the date of delivery ("Storage Fee"). Additionally, if Company is performing installation services and at the time of delivery Buyer's location is not ready or is unsafe for installation, Company reserves the right to postpone or to discontinue work. In such event, Company may charge Buyer an amount equivalent to the Storage Fee until such time that the location is ready and safe for installation, as determined by Company.
9. **Warranty** Company warrants, to purchasers from a Company authorized seller (each a "Buyer"), that the equipment manufactured by it and services provided by it will be free from defects in material and workmanship, for the duration of the specified Warranty Period. For new equipment, a period of twelve (12) months from the date of initial operation not to exceed eighteen (18) months from shipment, whichever first occurs, except for the Airend of new oil-flooded rotary screw air compressors, which is for the duration as detailed in the 5 Year Airend Parts Warranty below; for parts and services, six (6) months from the date of shipment; for services, six (6) months from the date of installation, inclusive of transportation and installation costs if installed by Company or six (6) months from the date of delivery exclusive of transportation and installation costs if not installed by Company (each a "Warranty Period"). Equipment or parts manufactured by others are warranted only to the extent of the original manufacturer's warranty to Company.
5 Year Airend Parts Warranty: Company Warrants , to a Buyer, that the Airend, as defined below, of new oil-flooded rotary screw air compressors manufactured by Company, will be free from defects in material and workmanship for a period of five (5) years from the date of initial operation not to exceed sixty-six (66) months from shipment, whichever occurs first.

10. **Order Cancellation** If Buyer cancels an order, Buyer will pay a cancellation fee to Company in an amount equal to Company's direct out of pocket costs incurred plus a percentage of the order value to cover sales and administrative expenses. The percentage is based on the proportion of time which has elapsed from the date the order is placed to the originally scheduled shipment date as follows:

Percent of time elapsed from PO date to scheduled ship date	Cancellation fee % of PO Value
0-10%	5%
11-20%	15%
21-30%	25%
31-40%	35%
41-50%	45%
51-60%	55%
61-70%	65%
71-80%	75%
81-90%	85%
91-100%	95%

11. **Compliance with Laws** Company will comply with all applicable laws and regulations in effect in the location of manufacture on the date an order is placed. Compliance with any local governmental laws or regulations relating to location, use, or operation of the equipment, or its use in conjunction with other equipment, will be the sole responsibility of Buyer. Equipment purchased hereunder is produced in accordance with all applicable requirements of Section 6, 7, and 12 of the Fair Labor Standards Act as amended and of regulations and orders of the United States Department of Labor issued under Section 14 thereof. Where applicable, the Federal Equal Credit Opportunity Act prohibits creditors from discrimination against credit applicants on the basis of race, color, religion, national origin, sex, marital status, or age (provided that the applicant has the capacity to enter into a binding contract); because of all or part of the applicant's income derives from any public assistance programs; or because the applicant has in good faith exercised any right under the Consumer Protection Act. The federal agency that administers compliance with this law concerning the creditor is the Federal Trade Commission, Washington, D.C.
12. **Data Privacy** Buyer understands and agrees that certain of the Products include technology that allows Company to collect technical and product-related information regarding such Products and to conduct remote diagnostics testing of such Products. This technology allows Company to better serve and assist Buyer in the event such Products need to be repaired, and to maintain and improve the Products. Buyer agrees to grant and hereby grants Company a transferable, sub-licensable, non-exclusive, non-revocable, worldwide right to access and use the data collected and processed by the technology for Company's business purposes, including analysis, research, and development. In addition, Company may share such information with its affiliates, subsidiaries, and service providers; and with third parties but only in an aggregate, de-identified format, with third parties for research, statistical and business purposes unless otherwise agreed to or in accordance with the applicable privacy policy. To the extent that Company receives any individually identifiable personal information regarding Buyer from such technology, Company's policy is to protect the confidentiality of such information, and to prohibit the unlawful disclosure of Buyer's personal information to third parties. Company will take reasonable steps to insure the safety of Buyer's personal information.
13. **Export Control** Buyer agrees not to disclose or export, either directly or indirectly, any Company technology or information, or the direct product thereof, to any destination or person if such disclosure or export is prohibited by U.S. laws and regulations. In particular, Buyer will not use and will not permit any third party to use Company technology or information in connection with the design, production, use or storage of chemical, biological or nuclear weapons or missiles of any kind. This paragraph will survive the termination of this contract.
14. **Patent Indemnity** Company will defend Buyer against any proceeding based upon a claim that the equipment manufactured by Company infringes any U.S. patent, provided that Company is promptly notified in writing and given authority, information, and assistance for defense of the same. If any claim materially interferes with Buyer's use of the equipment, Company will, at its option, procure for Buyer the right to continue to use such equipment, modify it so that it becomes non-infringing, replace it with non-infringing equipment, or will remove the equipment and refund the purchase price. Company does not accept any liability whatsoever in respect to patents claiming more than the equipment furnished hereunder or claiming methods or processes to be carried out with the aid of such equipment. The foregoing states the entire liability of Company with regard to patent infringement.
15. **Limitation of Liability** THE REMEDIES OF BUYER SET FORTH HEREIN ARE EXCLUSIVE, AND THE TOTAL LIABILITY OF COMPANY WITH RESPECT TO THIS CONTRACT, WHETHER BASED ON CONTRACT, WARRANTY, NEGLIGENCE, INDEMNITY, STRICT LIABILITY OR OTHERWISE, WILL NOT EXCEED THE PURCHASE PRICE FOR THE EQUIPMENT, PART OR SERVICE THAT IS THE BASIS FOR THE CLAIM. IN NO EVENT WILL COMPANY BE LIABLE TO BUYER, ANY SUCCESSORS IN INTEREST, OR ANY BENEFICIARY OR ASSIGNEE OF THIS CONTRACT FOR ANY CONSEQUENTIAL, INCIDENTAL, INDIRECT, SPECIAL, OR PUNITIVE DAMAGES, OR LOST PROFITS OR REVENUE ARISING OUT OF THIS CONTRACT OR ANY BREACH THEREOF, OR ANY DEFECT IN, OR FAILURE OF, OR MALFUNCTION OF THE EQUIPMENT, PART OR SERVICE HEREUNDER, WHETHER OR NOT SUCH LOSS OR DAMAGE IS BASED ON CONTRACT, WARRANTY, NEGLIGENCE, INDEMNITY, STRICT LIABILITY, OR OTHERWISE.
16. **Assignment** Buyer will not assign or transfer this contract without the prior written consent of Company, and such consent will not be unreasonably withheld. Additionally, Buyer will not sell all or a substantial portion of its assets to another entity (the "Successor") without the prior written consent of Company. In the event that Buyer does not provide such notice to Company and the business previously conducted by Buyer is or may be continued by the Successor, Buyer shall be liable for and shall pay on demand the amount of all accounts receivable due by Successor to Company arising from the date of such sale of assets to the date Company learns of such asset sale.
17. **No Waiver** No waiver by Company of any of the provisions of this Contract is effective unless explicitly set forth in writing and signed by Company. No failure to exercise, partial exercise, or delay in exercising, any right, remedy, power or privilege arising from this Contract operates, or may be construed, as a waiver thereof.
18. **Governing Law** The rights and obligations of the parties will be governed by the laws of the State of North Carolina excluding any conflict of law provisions. The United Nations Convention on Contracts for the International Sale of Goods will not apply to this contract.
19. **No Reference Required** Buyer and Company agree that each order shall constitute a separate contract, the performance of which will be governed exclusively by these Terms. This Agreement shall govern an order regardless of whether or not this document is attached to or referenced in the order. Excluded from applicability to an order include, but are not limited to: (i) any other terms and conditions contained in the order, including terms contained on the reverse side of the order; (ii) any reference in an order to Buyer's Internet site for terms and conditions; (iii) any reference in an order to any other agreement, document or terms unless agreed to in writing by the Parties. In the event of a conflict between any terms and conditions of an order (except (iii) above), Terms shall prevail and govern the order.



APPENDIX C

Cost Estimate



Sweetwater Authority
Sweetwater Reservoir Aeration/Destratification System
Preliminary Design
Estimate Summary - Work Breakdown Structure (WBS)

Description		Alt 1A	Alt 1B	Alt 2A	Alt 2B
	Sitework & Existing	\$ 1,569	\$ 1,569	\$ 1,569	\$ 1,569
	Compressors - Equipment	\$ 141,281	\$ 141,282	\$ 141,282	\$ 141,282
	Compressors - Structural & Shelter	\$ 47,968	\$ 47,968	\$ 47,968	\$ 47,968
	Aeration Piping	\$ 118,303	\$ 118,305	\$ 63,351	\$ 63,351
	Electrical & I+C	\$ 104,799	\$ 104,799	\$ 184,268	\$ 184,268
	Reservoir Diffuser Piping	\$ 183,000	\$ 266,000	\$ 183,000	\$ 266,000
	Subtotal:	\$ 596,920	\$ 679,923	\$ 621,438	\$ 704,438
	Small Tools (Applied on Labor) 2.0% on	\$ 130,644	\$ 130,644	\$ 138,365	\$ 138,365
	Small Tools (Applied on Labor) Total:	\$ 2,613	\$ 2,613	\$ 2,767	\$ 2,767
	Incidental Overtime (Applied on Labor) 2.0% on	\$ 130,644	\$ 130,644	\$ 138,365	\$ 138,365
	Incidental Overtime (Applied on Labor) Total:	\$ 2,613	\$ 2,613	\$ 2,767	\$ 2,767
	Direct Costs Subtotal:	\$ 602,146	\$ 685,149	\$ 626,973	\$ 709,973
	General Conditions 15.0% on	\$ 602,146	\$ 685,149	\$ 626,973	\$ 709,973
	General Conditions Total:	\$ 90,322	\$ 102,772	\$ 94,046	\$ 106,496
	Indirect Costs Subtotal:	\$ 90,322	\$ 102,772	\$ 94,046	\$ 106,496
	Direct and Indirect Costs Total:	\$ 692,468	\$ 787,921	\$ 721,018	\$ 816,468
	Add-On / Mark-Up				
	Labor Escalation 5.0% on	\$ 203,611	\$ 212,949	\$ 214,434	\$ 223,772
	Labor Escalation Total:	\$ 10,169	\$ 10,635	\$ 10,709	\$ 11,176
	Material / Equipment Escalation 7.2% on	\$ 492,979	\$ 579,093	\$ 506,584	\$ 592,697
	Material / Equipment Escalation Total:	\$ 35,280	\$ 41,442	\$ 36,253	\$ 42,416
	Subtotal:	\$ 737,916	\$ 839,999	\$ 767,981	\$ 870,060
	Subcontractor Overhead, Profit and Fee 25.0% on	\$ 443,250	\$ 532,192	\$ 473,381	\$ 562,321
	Subcontractor Overhead, Profit and Fee Total:	\$ 110,813	\$ 133,048	\$ 118,345	\$ 140,580
	Subtotal:	\$ 848,729	\$ 973,046	\$ 886,326	\$ 1,010,640
	Prime Contractor Overhead 10.0% on	\$ 294,666	\$ 307,807	\$ 294,600	\$ 307,739
	Prime Contractor Overhead Total:	\$ 29,467	\$ 30,781	\$ 29,460	\$ 30,774
	Subtotal:	\$ 878,196	\$ 1,003,827	\$ 915,786	\$ 1,041,414
	Prime Contractor Profit 10.0% on	\$ 324,133	\$ 338,588	\$ 324,060	\$ 338,513
	Prime Contractor Profit Total:	\$ 32,413	\$ 33,859	\$ 32,406	\$ 33,851
	Subtotal:	\$ 910,609	\$ 1,037,686	\$ 948,192	\$ 1,075,265
	Prime Profit on Subcontracted Work 5.0% on	\$ 554,063	\$ 665,240	\$ 591,726	\$ 702,901
	Prime Profit on Subcontracted Work Total:	\$ 27,703	\$ 33,262	\$ 29,586	\$ 35,145
	Subtotal:	\$ 938,312	\$ 1,070,948	\$ 977,779	\$ 1,110,411
	Bond and Insurance 3.0%	\$ 28,149	\$ 32,128	\$ 29,333	\$ 33,312
	Subtotal:	\$ 966,461	\$ 1,103,076	\$ 1,007,112	\$ 1,143,723
	Design Contingency 30.0%	\$ 289,938	\$ 330,923	\$ 302,134	\$ 343,117
	Subtotal:	\$ 1,256,400	\$ 1,433,999	\$ 1,309,246	\$ 1,486,840
	Contract Allowances and Unit Prices 0.0%				
	Total (rounded):	\$ 1,256,000	\$ 1,434,000	\$ 1,309,000	\$ 1,487,000

Description	Quantity	Unit	Notes	Total Unit Cost	Labor Amount	Equipment Amount	Material Amount	Total Amount
Location 1 - Alt A				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Demolish Existing Container & Equipment Pad	0	ea		\$ 4,121	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Prep site for new equipment pad	1	ea		\$ 1,569	\$ 1,107	\$ 462	\$ -	\$ 1,569
				\$ -	\$ -	\$ -	\$ -	\$ -
Compressor Equipment Pad	12	cy		\$ 714	\$ 4,286	\$ -	\$ 4,531	\$ 8,817
				\$ -	\$ -	\$ -	\$ -	\$ -
Metal structure - Compressor Shelter	1	ea		\$ 38,516	\$ 5,493	\$ 3,024	\$ 30,000	\$ 38,516
				\$ -	\$ -	\$ -	\$ -	\$ -
Air receiver tank equipment pad	1	cy	Approx 6' x 6'	\$ 714	\$ 309	\$ -	\$ 326	\$ 635
				\$ -	\$ -	\$ -	\$ -	\$ -
75 HP rotary screw air compressors, with air cooler & dryer	2	ea	Quote - Ingersoll Rand - 4/22	\$ -	\$ -	\$ -	\$ -	\$ -
Compressor - Oil Flooded	2	ea		\$ 47,675	\$ 22,776	\$ 3,024	\$ 69,550	\$ 95,350
Air Cooled Dryer	1	ea		\$ 20,791	\$ 2,847	\$ -	\$ 17,944	\$ 20,791
Compressed Filters	2	ea		\$ 2,919	\$ 1,424	\$ -	\$ 4,414	\$ 5,838
Oil-Water Separator	1	ea		\$ 8,834	\$ 2,847	\$ -	\$ 5,987	\$ 8,834
Air Receiver Tank	1	ea		\$ 10,469	\$ 658	\$ 504	\$ 9,307	\$ 10,469
				\$ -	\$ -	\$ -	\$ -	\$ -
Air Supply Piping				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Sawcut roadway	1,540	lf		\$ 2.29	\$ 2,315	\$ 813	\$ 400	\$ 3,528
Excavate roadway pavement	71	cy		\$ 7.88	\$ 395	\$ 167	\$ -	\$ 562
Haul & Dispose	82	cy		\$ 28	\$ 601	\$ 485	\$ 1,230	\$ 2,317
				\$ -	\$ -	\$ -	\$ -	\$ -
Excavate	570	cy		\$ 11	\$ 4,209	\$ 1,782	\$ -	\$ 5,991
Haul & Dispose	656	cy		\$ 18	\$ 4,810	\$ 3,883	\$ 3,280	\$ 11,973
Bedding	143	cy		\$ 59	\$ 2,105	\$ 1,671	\$ 4,636	\$ 8,411
Backfill	428	cy		\$ 36	\$ 3,062	\$ 993	\$ 11,499	\$ 15,553
				\$ -	\$ -	\$ -	\$ -	\$ -
Install 4" HDPE	770	lf		\$ 12	\$ 5,734	\$ 1,546	\$ 2,094	\$ 9,375
Bends/Fittings	19	ea		\$ 162	\$ 1,887	\$ 509	\$ 692	\$ 3,087
				\$ -	\$ -	\$ -	\$ -	\$ -
Install 4" HDPE Above Ground - Slope to Reservoir	50	lf		\$ 12	\$ 372	\$ 100	\$ 136	\$ 609
Equipment pad	1	ea		\$ 773	\$ 406	\$ -	\$ 367	\$ 773
Flow control manifold	1	ea		\$ 1,652	\$ 562	\$ -	\$ 1,090	\$ 1,652
Pressure gauges	2	ea		\$ 926	\$ 252	\$ -	\$ 1,600	\$ 1,852
Valves	2	ea		\$ 2,374	\$ 749	\$ -	\$ 4,000	\$ 4,749
Anchors/Supports	5	ea		\$ 603	\$ 1,565	\$ -	\$ 1,450	\$ 3,015
Pipe Sleeve	50	lf		\$ 402	\$ 6,770	\$ 3,436	\$ 9,911	\$ 20,117
				\$ -	\$ -	\$ -	\$ -	\$ -
Repave Roadway over trench	428	sy		\$ 58	\$ 8,465	\$ 4,409	\$ 11,867	\$ 24,741
				\$ -	\$ -	\$ -	\$ -	\$ -
Electrical Service				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Sawcut roadway	640	lf		\$ 2.03	\$ 962	\$ 338	\$ -	\$ 1,300
Excavate roadway pavement	30	cy		\$ 7.88	\$ 164	\$ 69	\$ -	\$ 233
Haul & Dispose	34	cy		\$ 28	\$ 250	\$ 202	\$ 511	\$ 963
				\$ -	\$ -	\$ -	\$ -	\$ -
Excavate	237	cy		\$ 11	\$ 1,749	\$ 741	\$ -	\$ 2,490
Haul & Dispose	273	cy		\$ 18	\$ 1,999	\$ 1,614	\$ 1,363	\$ 4,976
Concrete	107	cy		\$ 184	\$ 1,077	\$ 29	\$ 18,560	\$ 19,666
Duct Bank Conduit & Wire	320	lf		\$ 65	\$ 15,187	\$ -	\$ 5,728	\$ 20,915
Backfill	130	cy		\$ 36	\$ 933	\$ 303	\$ 3,504	\$ 4,740
				\$ -	\$ -	\$ -	\$ -	\$ -
Additional Electrical Allowance	1	ls		\$ 30,679	\$ 10,679	\$ -	\$ 20,000	\$ 30,679
Additional I&C Allowance	1	ls		\$ 18,837	\$ 8,837	\$ -	\$ 10,000	\$ 18,837
				\$ -	\$ -	\$ -	\$ -	\$ -
Underwater Diffuser System (Water Quality Solutions) - 500 ft	1	ea	Mobley - Estimate	\$ 183,000	\$ -	\$ -	\$ 183,000	\$ 183,000
				\$ -	\$ 127,843	\$ 30,102	\$ 438,975	\$ 596,920

Description	Quantity	Unit	Notes	Total Unit Cost	Labor Amount	Equipment Amount	Material Amount	Total Amount
Location 1 - Alt B				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Demolish Existing Container & Equipment Pad	0	ea		\$ 4,121	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Prep site for new equipment pad	1	ea		\$ 1,569	\$ 1,107	\$ 462	\$ -	\$ 1,569
				\$ -	\$ -	\$ -	\$ -	\$ -
Compressor Equipment Pad	12	cy		\$ 714	\$ 4,286	\$ -	\$ 4,531	\$ 8,817
				\$ -	\$ -	\$ -	\$ -	\$ -
Metal structure - Compressor Shelter	1	ea		\$ 38,516	\$ 5,493	\$ 3,024	\$ 30,000	\$ 38,516
				\$ -	\$ -	\$ -	\$ -	\$ -
Air receiver tank equipment pad	1	cy	Approx 6' x 6'	\$ 714	\$ 309	\$ -	\$ 326	\$ 635
				\$ -	\$ -	\$ -	\$ -	\$ -
75 HP rotary screw air compressors, with air cooler & dryer	2	ea	Quote - Ingersoll Rand - 4/22	\$ -	\$ -	\$ -	\$ -	\$ -
Compressor - Oil Flooded	2	ea		\$ 47,675	\$ 22,776	\$ 3,024	\$ 69,550	\$ 95,350
Air Cooled Dryer	1	ea		\$ 20,791	\$ 2,847	\$ -	\$ 17,944	\$ 20,791
Compressed Filters	2	ea		\$ 2,919	\$ 1,424	\$ -	\$ 4,414	\$ 5,838
Oil-Water Separator	1	ea		\$ 8,834	\$ 2,847	\$ -	\$ 5,987	\$ 8,834
Air Receiver Tank	1	ea		\$ 10,469	\$ 658	\$ 504	\$ 9,307	\$ 10,469
				\$ -	\$ -	\$ -	\$ -	\$ -
Air Supply Piping				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Sawcut roadway	1,540	lf		\$ 2.29	\$ 2,315	\$ 813	\$ 400	\$ 3,528
Excavate roadway pavement	71	cy		\$ 7.88	\$ 395	\$ 167	\$ -	\$ 562
Haul & Dispose	82	cy		\$ 28	\$ 601	\$ 485	\$ 1,230	\$ 2,317
				\$ -	\$ -	\$ -	\$ -	\$ -
Excavate	570	cy		\$ 11	\$ 4,209	\$ 1,782	\$ -	\$ 5,991
Haul & Dispose	656	cy		\$ 18	\$ 4,810	\$ 3,883	\$ 3,280	\$ 11,973
Bedding	143	cy		\$ 59	\$ 2,105	\$ 1,671	\$ 4,636	\$ 8,411
Backfill	428	cy		\$ 36	\$ 3,062	\$ 993	\$ 11,499	\$ 15,553
				\$ -	\$ -	\$ -	\$ -	\$ -
Install 4" HDPE	770	lf		\$ 12	\$ 5,734	\$ 1,546	\$ 2,094	\$ 9,375
Bends/Fittings	19	ea		\$ 162	\$ 1,887	\$ 509	\$ 692	\$ 3,087
				\$ -	\$ -	\$ -	\$ -	\$ -
Install 4" HDPE Above Ground - Slope to Reservoir	50	lf		\$ 12	\$ 372	\$ 100	\$ 136	\$ 609
Equipment pad	1	ea		\$ 773	\$ 406	\$ -	\$ 367	\$ 773
Flow control manifold	1	ea		\$ 1,652	\$ 562	\$ -	\$ 1,090	\$ 1,652
Pressure gauges	2	ea		\$ 926	\$ 252	\$ -	\$ 1,600	\$ 1,852
Valves	2	ea		\$ 2,374	\$ 749	\$ -	\$ 4,000	\$ 4,749
Anchors/Supports	5	ea		\$ 603	\$ 1,565	\$ -	\$ 1,450	\$ 3,015
Pipe Sleeve	50	lf		\$ 402	\$ 6,770	\$ 3,436	\$ 9,911	\$ 20,117
				\$ -	\$ -	\$ -	\$ -	\$ -
Repave Roadway over trench	428	sy		\$ 58	\$ 8,465	\$ 4,409	\$ 11,867	\$ 24,741
				\$ -	\$ -	\$ -	\$ -	\$ -
Electrical Service				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Sawcut roadway	640	lf		\$ 2.03	\$ 962	\$ 338	\$ -	\$ 1,300
Excavate roadway pavement	30	cy		\$ 7.88	\$ 164	\$ 69	\$ -	\$ 233
Haul & Dispose	34	cy		\$ 28	\$ 250	\$ 202	\$ 511	\$ 963
				\$ -	\$ -	\$ -	\$ -	\$ -
Excavate	237	cy		\$ 11	\$ 1,749	\$ 741	\$ -	\$ 2,490
Haul & Dispose	273	cy		\$ 18	\$ 1,999	\$ 1,614	\$ 1,363	\$ 4,976
Concrete	107	cy		\$ 184	\$ 1,077	\$ 29	\$ 18,560	\$ 19,666
Duct Bank Conduit & Wire	320	lf		\$ 65	\$ 15,187	\$ -	\$ 5,728	\$ 20,915
Backfill	130	cy		\$ 36	\$ 933	\$ 303	\$ 3,504	\$ 4,740
Additional Electrical Allowance	1	ls		\$ 30,679	\$ 10,679	\$ -	\$ 20,000	\$ 30,679
Additional I&C Allowance	1	ls		\$ 18,837	\$ 8,837	\$ -	\$ 10,000	\$ 18,837
				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Underwater Diffuser System (Water Quality Solutions) - 2000 ft	1	ea	Mobley - Estimate	\$ 266,000	\$ -	\$ -	\$ 266,000	\$ 266,000
				\$ -	\$ 127,843	\$ 30,102	\$ 521,975	\$ 679,920

Description	Quantity	Unit	Notes	Total Unit Cost	Labor Amount	Equipment Amount	Material Amount	Total Amount
Location 2 - Alt A				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Prep site for equipment pad	1	ea		\$ 1,569	\$ 1,107	\$ 462	\$ -	\$ 1,569
				\$ -	\$ -	\$ -	\$ -	\$ -
Compressor Equipment Pad	12	cy		\$ 714	\$ 4,286	\$ -	\$ 4,531	\$ 8,817
				\$ -	\$ -	\$ -	\$ -	\$ -
Metal structure - Compressor Shelter	1	ea		\$ 38,516	\$ 5,493	\$ 3,024	\$ 30,000	\$ 38,516
				\$ -	\$ -	\$ -	\$ -	\$ -
Air receiver tank equipment pad	1	cy	Approx 6' x 6'	\$ 714	\$ 309	\$ -	\$ 326	\$ 635
				\$ -	\$ -	\$ -	\$ -	\$ -
75 HP rotary screw air compressors, with air cooler & dryer	2	ea	Quote - Ingersoll Rand - 4/22	\$ -	\$ -	\$ -	\$ -	\$ -
Compressor - Oil Flooded	2	ea		\$ 47,675	\$ 22,776	\$ 3,024	\$ 69,550	\$ 95,350
Air Cooled Dryer	1	ea		\$ 20,791	\$ 2,847	\$ -	\$ 17,944	\$ 20,791
Compressed Filters	2	ea		\$ 2,919	\$ 1,424	\$ -	\$ 4,414	\$ 5,838
Oil-Water Separator	1	ea		\$ 8,834	\$ 2,847	\$ -	\$ 5,987	\$ 8,834
Air Receiver Tank	1	ea		\$ 10,469	\$ 658	\$ 504	\$ 9,307	\$ 10,469
				\$ -	\$ -	\$ -	\$ -	\$ -
Air Supply Piping				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Sawcut roadway	550	lf		\$ 2.29	\$ 827	\$ 290	\$ 143	\$ 1,260
Excavate roadway pavement	25	cy		\$ 7.88	\$ 141	\$ 60	\$ -	\$ 201
Haul & Dispose	29	cy		\$ 28	\$ 215	\$ 173	\$ 439	\$ 827
				\$ -	\$ -	\$ -	\$ -	\$ -
Excavate	204	cy		\$ 11	\$ 1,503	\$ 636	\$ -	\$ 2,140
Haul & Dispose	234	cy		\$ 18	\$ 1,718	\$ 1,387	\$ 1,171	\$ 4,276
Bedding	51	cy		\$ 59	\$ 752	\$ 597	\$ 1,656	\$ 3,004
Backfill	153	cy		\$ 36	\$ 1,094	\$ 355	\$ 4,107	\$ 5,555
				\$ -	\$ -	\$ -	\$ -	\$ -
Install 4" HDPE	275	lf		\$ 12	\$ 2,048	\$ 552	\$ 748	\$ 3,348
Bends/Fittings	7	ea		\$ 162	\$ 695	\$ 187	\$ 255	\$ 1,137
				\$ -	\$ -	\$ -	\$ -	\$ -
Install 4" HDPE Above Ground - Slope to Reservoir	50	lf		\$ 12	\$ 372	\$ 100	\$ 136	\$ 609
Equipment pad	1	ea		\$ 773	\$ 406	\$ -	\$ 367	\$ 773
Flow control manifold	1	ea		\$ 1,652	\$ 562	\$ -	\$ 1,090	\$ 1,652
Pressure gauges	2	ea		\$ 926	\$ 252	\$ -	\$ 1,600	\$ 1,852
Valves	2	ea		\$ 2,374	\$ 749	\$ -	\$ 4,000	\$ 4,749
Anchors/Supports	5	ea		\$ 603	\$ 1,565	\$ -	\$ 1,450	\$ 3,015
Pipe Sleeve	50	lf		\$ 402	\$ 6,770	\$ 3,436	\$ 9,911	\$ 20,117
				\$ -	\$ -	\$ -	\$ -	\$ -
Repave Roadway over trench	153	sy		\$ 58	\$ 3,023	\$ 1,575	\$ 4,238	\$ 8,836
				\$ -	\$ -	\$ -	\$ -	\$ -
Electrical Service				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Sawcut roadway	1,560	lf		\$ 2.03	\$ 2,345	\$ 824	\$ -	\$ 3,169
Excavate roadway pavement	72	cy		\$ 7.88	\$ 400	\$ 169	\$ -	\$ 569
Haul & Dispose	83	cy		\$ 28	\$ 609	\$ 492	\$ 1,246	\$ 2,347
				\$ -	\$ -	\$ -	\$ -	\$ -
Excavate	578	cy		\$ 11	\$ 4,264	\$ 1,805	\$ -	\$ 6,069
Haul & Dispose	664	cy		\$ 18	\$ 4,873	\$ 3,933	\$ 3,322	\$ 12,128
Concrete	260	cy		\$ 184	\$ 2,625	\$ 70	\$ 45,240	\$ 47,935
Duct Bank Conduit & Wire	780	lf		\$ 65	\$ 37,019	\$ -	\$ 13,962	\$ 50,981
Backfill	318	cy		\$ 36	\$ 2,275	\$ 737	\$ 8,542	\$ 11,554
				\$ -	\$ -	\$ -	\$ -	\$ -
Additional Electrical Allowance	1	ls		\$ 30,679	\$ 10,679	\$ -	\$ 20,000	\$ 30,679
Additional I&C Allowance	1	ls		\$ 18,837	\$ 8,837	\$ -	\$ 10,000	\$ 18,837
				\$ -	\$ -	\$ -	\$ -	\$ -
Underwater Diffuser System (Water Quality Solutions) - 500 ft	1	ea	Mobley - Estimate	\$ 183,000	\$ -	\$ -	\$ 183,000	\$ 183,000
				\$ -	\$ 138,363	\$ 24,392	\$ 458,680	\$ 621,436

Description	Quantity	Unit	Notes	Total Unit Cost	Labor Amount	Equipment Amount	Material Amount	Total Amount
Location 2 - Alt B				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Prep site for equipment pad	1	ea		\$ 1,569	\$ 1,107	\$ 462	\$ -	\$ 1,569
				\$ -	\$ -	\$ -	\$ -	\$ -
Compressor Equipment Pad	12	cy		\$ 714	\$ 4,286	\$ -	\$ 4,531	\$ 8,817
				\$ -	\$ -	\$ -	\$ -	\$ -
Metal structure - Compressor Shelter	1	ea		\$ 38,516	\$ 5,493	\$ 3,024	\$ 30,000	\$ 38,516
				\$ -	\$ -	\$ -	\$ -	\$ -
Air receiver tank equipment pad	1	cy	Approx 6' x 6'	\$ 714	\$ 309	\$ -	\$ 326	\$ 635
				\$ -	\$ -	\$ -	\$ -	\$ -
75 HP rotary screw air compressors, with air cooler & dryer	2	ea	Quote - Ingersoll Rand - 4/22	\$ -	\$ -	\$ -	\$ -	\$ -
Compressor - Oil Flooded	2	ea		\$ 47,675	\$ 22,776	\$ 3,024	\$ 69,550	\$ 95,350
Air Cooled Dryer	1	ea		\$ 20,791	\$ 2,847	\$ -	\$ 17,944	\$ 20,791
Compressed Filters	2	ea		\$ 2,919	\$ 1,424	\$ -	\$ 4,414	\$ 5,838
Oil-Water Separator	1	ea		\$ 8,834	\$ 2,847	\$ -	\$ 5,987	\$ 8,834
Air Receiver Tank	1	ea		\$ 10,469	\$ 658	\$ 504	\$ 9,307	\$ 10,469
				\$ -	\$ -	\$ -	\$ -	\$ -
Air Supply Piping				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Sawcut roadway	550	lf		\$ 2.29	\$ 827	\$ 290	\$ 143	\$ 1,260
Excavate roadway pavement	25	cy		\$ 7.88	\$ 141	\$ 60	\$ -	\$ 201
Haul & Dispose	29	cy		\$ 28	\$ 215	\$ 173	\$ 439	\$ 827
				\$ -	\$ -	\$ -	\$ -	\$ -
Excavate	204	cy		\$ 11	\$ 1,503	\$ 636	\$ -	\$ 2,140
Haul & Dispose	234	cy		\$ 18	\$ 1,718	\$ 1,387	\$ 1,171	\$ 4,276
Bedding	51	cy		\$ 59	\$ 752	\$ 597	\$ 1,656	\$ 3,004
Backfill	153	cy		\$ 36	\$ 1,094	\$ 355	\$ 4,107	\$ 5,555
				\$ -	\$ -	\$ -	\$ -	\$ -
Install 4" HDPE	275	lf		\$ 12	\$ 2,048	\$ 552	\$ 748	\$ 3,348
Bends/Fittings	7	ea		\$ 162	\$ 695	\$ 187	\$ 255	\$ 1,137
				\$ -	\$ -	\$ -	\$ -	\$ -
Install 4" HDPE Above Ground - Slope to Reservoir	50	lf		\$ 12	\$ 372	\$ 100	\$ 136	\$ 609
Equipment pad	1	ea		\$ 773	\$ 406	\$ -	\$ 367	\$ 773
Flow control manifold	1	ea		\$ 1,652	\$ 562	\$ -	\$ 1,090	\$ 1,652
Pressure gauges	2	ea		\$ 926	\$ 252	\$ -	\$ 1,600	\$ 1,852
Valves	2	ea		\$ 2,374	\$ 749	\$ -	\$ 4,000	\$ 4,749
Anchors/Supports	5	ea		\$ 603	\$ 1,565	\$ -	\$ 1,450	\$ 3,015
Pipe Sleeve	50	lf		\$ 402	\$ 6,770	\$ 3,436	\$ 9,911	\$ 20,117
				\$ -	\$ -	\$ -	\$ -	\$ -
Repave Roadway over trench	153	sy		\$ 58	\$ 3,023	\$ 1,575	\$ 4,238	\$ 8,836
				\$ -	\$ -	\$ -	\$ -	\$ -
Electrical Service				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
				\$ -	\$ -	\$ -	\$ -	\$ -
Sawcut roadway	1,560	lf		\$ 2.03	\$ 2,345	\$ 824	\$ -	\$ 3,169
Excavate roadway pavement	72	cy		\$ 7.88	\$ 400	\$ 169	\$ -	\$ 569
Haul & Dispose	83	cy		\$ 28	\$ 609	\$ 492	\$ 1,246	\$ 2,347
				\$ -	\$ -	\$ -	\$ -	\$ -
Excavate	578	cy		\$ 11	\$ 4,264	\$ 1,805	\$ -	\$ 6,069
Haul & Dispose	664	cy		\$ 18	\$ 4,873	\$ 3,933	\$ 3,322	\$ 12,128
Concrete	260	cy		\$ 184	\$ 2,625	\$ 70	\$ 45,240	\$ 47,935
Duct Bank Conduit & Wire	780	lf		\$ 65	\$ 37,019	\$ -	\$ 13,962	\$ 50,981
Backfill	318	cy		\$ 36	\$ 2,275	\$ 737	\$ 8,542	\$ 11,554
				\$ -	\$ -	\$ -	\$ -	\$ -
Additional Electrical Allowance	1	ls		\$ 30,679	\$ 10,679	\$ -	\$ 20,000	\$ 30,679
Additional I&C Allowance	1	ls		\$ 18,837	\$ 8,837	\$ -	\$ 10,000	\$ 18,837
				\$ -	\$ -	\$ -	\$ -	\$ -
Underwater Diffuser System (Water Quality Solutions) - 2000 ft	1	ea	Mobley - Estimate	\$ 266,000	\$ -	\$ -	\$ 266,000	\$ 266,000
				\$ -	\$ 138,363	\$ 24,392	\$ 541,680	\$ 704,436