NEEDS ASSESSMENT MEMORANDUM

DCRSD LSWRF Biofilter Evaluation

B&V PROJECT NO. 197305

PREPARED FOR

Delaware County Regional Sewer District

2 APRIL 2018

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1.0 INTRODUCTION

The Delaware County Regional Sewer District (District) has recently commenced operations at the Lower Scioto Water Reclamation Facility (LSWRF). Construction of the LSWRF was completed in 2007, but the facility has just now begun receiving flow. The District is in the process of accessing the various systems at the facility.

The LSWRF has air quality control facilities consisting of two biofilters to treat foul air from various sources within the WRF:

- Pretreatment Biofilter treats air from the Pretreatment Building Screening Room, screen channels and associated flow splitters.
- Solids Handling Biofilter treats air from aerobic digester No. 1, aerobic digester No. 2, raw sewage pump station wet wells, sludge loading bay and the centrifuge.

The biofilters have not been operated since construction was completed in 2007, and are in overall poor condition with multiple failing or failed components. Therefore, the District has commissioned an evaluation of the biofilter systems in order to evaluate their existing condition and determine the extent of necessary system repairs to allow for proper long-term operation.

The following memorandum provides an evaluation of the various air quality control unit components, with recommendations for improvements to provide adequate ventilation, odor control and corrosion protection. Also included is a discussion on alternative treatment and odor mitigation methods.

2.0 NEEDS ASSESSMENT

For this evaluation, review of the LSWRF record drawings and visual inspection of the facility were performed to establish whether the odor control systems will provide adequate ventilation, odor control and corrosion prevention within the spaces serviced by the two biofilters. This evaluation includes:

- Ventilation Assessment – Confirmation of the required ventilation rate for each unit process based on code requirements as well as odor and corrosion control.
- Foul Air Duct/Pipe Sizing Review – Review of the duct sizing based upon the required air flow rates and the associated system pressure of the piping system.
- Fan Evaluation – Review of the existing fans to confirm their ability to convey the required ventilation rates at the given system pressures.
- Biofilter Cell and Air Distribution System Review – Review of the biofilter system to ensure that the air distribution system and media composition will properly remove the odors based upon the loading and ventilation rates.
- Irrigation System Evaluation – Review of the irrigation system to ensure that adequate and even moisture will be provided to the biofilter media to provide the proper environment for microbial growth.

2.1 VENTILATION ASSESSMENT

The ventilation required for each process area is dictated by a combination of code requirements and also the ventilation rate needed to reduce the concentrations of odor and corrosion causing compounds within the space. National Fire Protection Association (NFPA) 820 – Standard for Fire Protection in Wastewater Treatment and Collection Facilities contains classifications for the various process areas within wastewater treatment facilities. These classifications dictate the National Electrical Code (NEC) area classification for given ventilation rates in each space. Both NFPA 820 and industry best practices for ventilation of the classified areas were considered in determining the necessary ventilation rates for both the Pretreatment and Solids Handling biofilters.

2.1.1 Pretreatment Building

Based on our site visit and a review of the record drawings, the configuration of the Pretreatment Building ventilation system will result in the presence of odorous and corrosive gases within the screening room due to the configuration of the supply and exhaust duct. Odors will originate from the open screen channels within the room. Foul air is removed from the upper head space, at the northern end of the screening room, with powered makeup air being supplied into the southern end upper head space. This configuration will result in air circulating only in the upper portion of the room. The ventilation of the space was designed such that the capacity of the powered exhaust fan exceeds that of the powered supply fan by approximately 300 cubic feet per minute (CFM). This will ensure that the room is maintained at a slightly negative pressure as compared to the exterior atmosphere. This is a common practice and will contain odorous gasses inside the building if the doors to the space are closed.

Industry best practices dictate that odors and corrosive air should be removed as close as possible to the source. The current configuration of the exhaust and supply duct unnecessarily forces corrosive air near the open channel surface into the room. The existing ventilation conditions of the Pretreatment Building are summarized in the following Table 2-1.

Table 2-1 Pretreatment and Blower Building Actual vs. Required Ventilation

PRETREATMENT/ BLOWER BUILDING	POWERED SUPPLY (CFM)	POWERED EXHAUST VENTILATION (CFM)	VENTILATION REQUIRED BY NFPA 820 (CFM)
Screening Room	4,400	4,700	4,700 (1) (2)
Blower Room*	3,150	3,150	Not Required

* Area not serviced by odor control system
(1) Min 12 air changes per hour: Class 1, Group D, Division 2 Classified Space
(2) Less than 12 air changes per hour: Class 1, Group D, Division 1 Classified Space

The required ventilation rate for the screening room should be verified with the separate code review being performed at the plant. If the attic area of the building is not separated from the screening room by a rated barrier, the required ventilation rate would increase to approximately 6,300 CFM. For the purposes of this memorandum, the existing ventilation rate of 4,700 CFM was utilized since the attic space could be ventilated separately and would not require odor control.

2.1.2 Solids Handling System

Multiple areas within, and surrounding, the Solids Handling Building will contribute to odorous air generation. The following areas are ventilated through the biofilter for odor mitigation.

Sludge Room. Odors in this space are a result of activities from the dewatering centrifuge and cake screw conveyor. The original design for this facility intended for a foul air duct to be directly connected to the dewatering centrifuge. This connection was never performed, and the duct instead pulls air from the lower headspace of the room. Supplemental ventilation is provided for this room; air is directly discharged outside of the building to atmosphere without being treated through the biofilter.

Sludge Loading Bay. As sludge cake is deposited from the screw conveyor into the disposal truck, odors will be generated. There is an air duct connection to the existing screw conveyor that is used to load the sludge into the truck. Ventilation is also provided for the truck loading bay. Air is removed at two points from the upper head space of the bay, and passive makeup air is provided at the opposite side of the room from a large wall louver located near the floor. The ventilation configuration should provide adequate air circulation throughout the room, and sufficiently mitigate most odors generated within the space when the doors are closed. However, it should be noted that powered supply air was not noted in the space which may not meet the requirements of NFPA 820.

Raw Sewage Pump Station. Ventilation for this deep chamber is provided near the upper head space of each wet well. Gooseneck vents provide passive ventilation with the intention of providing makeup air. However, the influent sewer will contribute significant air flow into the wet well due to the velocity of the wastewater flow within the pipe. Given the air flow entering the wet well through the influent sewer and the withdraw near the top of the wet well, this arrangement should be sufficient at curtailing the majority of odors generated in the space since most of the make up air will originate in the influent sewer . A simple flap valve is recommended for the goose neck vent pipes to prevent fresh air from short circuiting into the wet well. The precise designed ventilation rate of the space is unknown, based on the size of the foul air piping, it would appear that the ventilation rate is fairly low and may not be adequate to prevent the build up of corrosive gases. An analysis of the influent sewer air flow should be conducted to confirm the necessary air flow rate. For the purpose of this analysis, an air flow of 12 air changes per hour was utilized.

Aerobic Digesters. The majority of odor load and air flow to the biofilter will originate from the two aerobic digesters. The structures are both fully enclosed, with ventilation configured such that good sweep air is provided across the open head space. Ventilation provided to the space should reduce the potential for corrosion, as much as is possible for the given environment. Each digester is aerated at 1500 CFM. Given the type of cover system used for the digesters, it is recommended that the ventilation rate should be approximately 25% greater than the aeration rate to prevent fugitive odor emissions from the digesters. The covers are not air tight and will allow some fugitive odor emissions from the digester head space if the ventilation rate is not adequate.

The existing ventilation conditions of the Solids Handling Building and Raw Sewage Pump Station are summarized in the following Table 2-2

Table 2-2 Solids Handling Building and Raw Sewage Pump Station Actual vs. Required Ventilation

SOLIDS HANDLING BUILDING	POWERED EXHAUST (CFM)	EXISTING TREATED VENTILATION (CFM)	VENTILATION REQUIRED BY NFPA 820 (CFM)	RECOMMENDED TREATED VENTILATION (CFM)
Sludge Room Centrifuge	(1)	200	---	250
Sludge Room (untreated foul air)	1,000	---	900 (6) (7)	---
Sludge Loading Bay	(1)	1,800	2,100 (6) (7)	2,100
Sludge Loading Conveyor	(1)	200	---	250
Raw Sewage Pump Station	(1)	400	2,000 (2) (4)	2,000
Aerobic Digesters	(1)	3,800	10,800 (2)(3)(4)(5)	3,800
Blower Room*	9,000	---	Not Required	---
Lower Level*	1,300	---	1,300 (6) (7)	---
Totals		6,400		8,400

* Area not serviced by odor control system
(1) Ventilation provided by the main foul air fan.
(2) Min 12 air changes per hour: Class 1, Group D, Division 2 Classified Space
(3) Min 12 air changes per hour: Unclassified space *(Exterior, 18-inches surrounding tank)*
(4) Less than 12 air changes per hour: Class 1, Group D, Division 1 Classified Space
(5) Less than 12 air changes per hour: Class 1, Group D, Division 2 Classified Space *(Exterior, 18-inches surrounding tank)*
(6) Min 6 air changes per hour: Unclassified space
(7) Less than 6 air changes per hour: Class 1, Group D, Division 2 Classified Space

- NFPA 820 requires both powered supply and exhaust in many instances. There is no powered supply for the Solids Processing Building. It is possible that additional building HVAC upgrades will be required. The separate code review being performed at the plant should identify these deficiencies.

- The existing centrifuge has no port for the foul air connection. The connection point and recommended flow rate will need to be confirmed with the manufacturer. A nominal flow rate of 250 CFM was used for estimating purposes and should be a conservatively realistic value.

- The ventilation rate of the Raw Sewage Pump Station wet well will need to be evaluated. It is unknown if any corrosion protective coatings were utilized on the wet well concrete. If coatings were not utilized, the ventilation rate may need to be increased to reduce the levels of corrosive gases in the wet well. Additional data on the influent sewer will be needed along with monitoring of H2S levels if possible. The influent sewer flow characteristics will dictate how much air is being pulled into the wet well through the sewer along with the concentrations of odor and corrosion causing compounds.

2.2 FOUL AIR DUCT

Both the pretreatment and solids handling odor control systems utilize high density polyethylene (HDPE) buried piping to convey foul air from odor generating areas. All above grade/exposed foul air piping/duct is fiber reinforced plastic (FRP). The size and material of the piping was analyzed along with the volume of treated air to determine if friction losses fall within acceptable ranges. Pipe losses with excessive friction loss are generally considered to be undersized. In general, ducts are typically sized for a friction loss of approximately 0.1 in-H_2O/100 feet. This minimizes friction losses while providing reasonable duct sizes. The following section also provides observations regarding the general configuration of the piping systems. Figures A-1 and A-2 provide a schematic of each biofilter system showing existing and recommended foul air duct sizing.

2.2.1 Pretreatment Building

Foul Air Fan Discharge to Biofilter. For the pretreatment building biofilter, 24-inch corrugated HDPE pipe is utilized for buried sections of foul air duct downstream of the odor control fan discharge.

- The Buried foul air duct is shallow, averaging 3 to 4 feet in depth.
- Air duct slopes away from the building at 0.25%. A condensation drain with trap is provided at the end of the air duct, and connected to a nearby sanitary sewer. A cleanout was not provided with the trap.
- The approximate length of duct is 88 feet, with an estimated flowrate of 4,700 CFM.
- Friction Losses at this flow rate are approximately 0.12 in-H_2O/100 feet which is acceptable.

Foul Air Intake. A single 20" FRP duct is used to ventilate the pretreatment building. The duct inlet is near the ceiling which will not provide an optimal ventilation pattern as discussed previously.

- See Figure A-3 for the recommended foul air duct configuration inside the pretreatment building. Please note that the layout is conceptual and would require further refinement prior to construction.

2.2.2 Solids Handling

Foul Air Fan Discharge to Biofilter. 24-inch corrugated HDPE pipe is utilized for buried sections of foul air duct downstream of the odor control fan discharge.

- Buried foul air duct is shallow, averaging 3 to 4 feet in depth.
- Buried foul air duct installed parallel to the biofilter (north-to-south) slopes away from the Solids Handling building at 0.25%. A condensate drain is provided at the end of the air duct, and connected to a nearby sanitary sewer. No detail provided to indicate a trap was provided, which could be a potential source of foul air release into the sanitary manhole and then atmosphere.
- Buried foul air duct installed east to west is sloped back towards the building and foul air fan. At the time of our site visit, water was leaking into the fan housing at a rate of at least 5

gpm. A visual inspection of any duct to be reused should be performed to confirm the source of the leaks. The buried HDPE pipe used appears to be Advanced Drainage Systems (ADS) N-12 which has a silt tight gasketed joint. Failure of the joints resulting in leakage would not be surprising even at a shallow burial depth . If multiple joints are leaking, we would recommend utilizing FRP pipe (Hobas or Flow Tite) as the best option. A less expensive option would be the ADS Sani Tite which is still a flexible pipe with a less robust gasketed joint. However, it would still be superior to the ADS N-12 piping that was utilized originally.

- Friction losses at the recommended ventilation flow rate of 8400 CFM are approximately 0.4 in-H_2O/100 feet for the existing 24-inch pipe. It is recommended that the foul air discharge pipe size be increased to 30-inch to reduce friction losses to approximately 0.1 in-H_2O/100 feet. See Figure A-2 for the recommended foul air duct sizes for the Solids Handling foul air system.

Raw Sewage Pump Station. Two, 8-inch HDPE air ducts are connected into the wet well upper head space. Foul air duct connects to wet well at centerline (C/L) elevation (EL) 936.5. This elevation is lower than where the buried foul air suction duct enters the Solids Handling building at C/L EL 938.5. It is assumed that these lines double as condensation drains for the larger buried section of foul air duct.

- Each foul air duct has an approximate length of 40 feet, with an estimated recommended flowrate of 1,000 CFM. Friction Losses at this flow rate in the existing 8-inch ducts are 1.5 in-H_2O/100 feet which is excessive. It is recommended that the foul air pipe size be increased to 15-inch to bring the pressure loss down to approximately 0.1 in-H_2O/100 feet.

Aerobic Digesters. Two, 15-inch HDPE foul air ducts collect foul air from each digester, for a total of four runs of pipe. The main buried air trunk increases from 15-inches to 24 inches before entering the basement.

- Each foul air duct has an approximate length 35 feet, with a recommended ventilation rate of 1900 CFM. Friction Losses at this flow rate are approximately 0.2 in-H_2O/100 feet which should be acceptable given the relatively short duct length.

Solids Handling Main Trunk Air Duct.

- Due to the increase in air flow from the raw sewage pump station, portions of the main trunk duct will need to be upsized to reduce system pressure losses. See Figure A-2 for more detail.

- While water was not observed leaking from the main air collection duct, it should also be inspected for leaking joints or other damage prior to placing the system in service.

Sludge Loading Room. One, 6-inch duct is connected to the truck fill boom. Centrifuge duct and loadout duct combine into 18” duct before elbowing down towards the basement.

- The total approximate length of exposed 18-inch foul air duct is 36 feet, with an estimated flowrate of 2,100 CFM. Friction losses at this flow rate are approximately 0.1 in-H_2O/100 feet.

Sludge Room. One, 6-inch foul air duct to the centrifuge is provided but not connected. The foul air duct appears to be slightly undersized for the approximate air flow rate of 250 CFM. However, this air flow rate is likely at the high end of the air flow rate range needed for the centrifuge, and the duct run is relatively short.

2.3 FOUL AIR FANS

The following is an evaluation of the fans based upon the required ventilation rate and system pressures. In general, all of the existing equipment has been inoperative for a number of years. Any equipment to be reused should be thoroughly examined by the manufacturer's representative to determine any necessary repairs or maintenance. We would recommend inspection of the motors, fan shaft bearings, sheaves, belts, fan housing and wheels at a minimum. It is likely that many components will need to be replaced.

2.3.1 Pretreatment

The existing fan is located in the northwest corner of the pretreatment building on the operating level. The fan did not show any visible signs of damage, but a detailed inspection was not performed. The fan does sit higher than any of the buried piping, so it may not have been subjected to the same water damage as the Solids Handling system fan. The fan is currently sized for 4700 CFM at 12 in-H_2O. This flow rate and operating pressure should be sufficient to provide adequate ventilation to the pretreatment building and convey foul air through the discharge piping and the biofilter media bed. Overall system pressures are expected to be less than the fan's rated pressure. It was noted that flexible connections were not provided at the duct connections to the fan. Flexible connections are recommended to prevent vibration from the fan from impacting the structural integrity of the duct and associated supports.

2.3.2 Solids Handling

The existing fan is located in the northeast corner of the Sludge Pump Room on the lower level of the Solids Handling building. The fan had sustained damage from the flooding of the lower level and water intrusion into the foul air ducts. The existing fan was sized for 6,400 CFM at 14 in-H_2O. The recommended air flow rate for the areas to be served by this fan was increased to 8,400 CFM, so we would recommend a replacement fan based on the damage to the existing fan and the increased air flow rate. The system pressure should be significantly less than the original system pressure, and for estimation purposes, we used 9 in-H_2O as the operating point. It should be noted that the system pressure for the engineered media biofilter system would likely be higher. We would also recommend relocating the fan just outside the wall of the Solids Handling building near the biofilter. A weatherproof enclosure for the fan is relatively inexpensive, and this would keep the fan at the high point in the foul air system which minimizes the chance for water damage.

2.4 BIOFILTER CELLS AND AIR DISTRIBUTION

The configuration of the biofilter cells and the media composition are key components to a functional odor control system. A brief visual inspection of each biofilter was performed, and the following issues were noted:

- The organic media has composted and will need to be replaced. Since the system had not been in operation, the composting is simply due to age and lack of air flow. However, the shredded hardwood media used in the existing design will have a life span of approximately 2-3 years.
- The 8" air distribution laterals were installed several inches above the floor. This caused multiple problems:
  - Many of the 8" lines sheared off at the wall when the media under the pipe settled.
  - Having the air headers several inches above the floor shortens the media contact time.
- The washed gravel used at the base of the biofilter has a high limestone content. Limestone and other sedimentary rocks with calcite cement between the sediment particles are subject to corrosion by the acidic biofilter leachate. Therefore, the aggregate media will need to be replaced with a corrosion resistant material.
- The loading rate for the existing biofilters is approximately 3 CFM/SF. This is a common practice/standard for the type of media originally used for the biofilter. The recommended media is significantly different from the original shredded wood chips. With the recommended media, a loading rate of at least 5 CFM/SF is recommended. If the loading rate is too low, the air distribution in the cells tends to be poor. When the air distribution is poor, pockets of the media will start to compost which exacerbates the poor air distribution. The end result is poor odor removal efficiency due to a lower media contact time since only portions of the bed are treating a higher flow rate. Eventually the poor air distribution can lead to short circuiting of the air in a small percentage of the overall bed area which can result in little to no odor removal.
- The empty bed contact time (EBCT) for the existing biofilters was approximately 105 seconds. While a longer EBCT usually allows for higher removal efficiency, it has to be balanced with the loading rate. A high EBCT with a low loading rate will result in poor air distribution which, in turn, leads to poor odor removal efficiency. Currently, we would target an EBCT of 60 to 90 seconds.
- The cell geometry results in the media being mounded on 3 sides. While this practice was very common in the past, most current designs use vertical walls for several reasons. The mounding results in an excess quantity of media that is not used for treatment around the perimeter. The perimeter sees less air flow and composts at an accelerated rate causing differential settlement along the perimeter of the cell. This settlement can create pathways for air to short circuit through the media with very low odor removal efficiency.

- None of the existing concrete surfaces had any type of corrosion protection. While the concrete appeared to be in good condition, the facilities have not been treating foul air. The leachate from the biofilter media will be acidic and corrosive to concrete.

2.4.1 Pretreatment Biofilter

As discussed above, the Pretreatment Facility biofilter serves to treat air from within the pre-treatment building screening room, and the flow rate to the biofilter is 4700 CFM. Due to the condition of the existing media, we would recommend replacing all of the biofilter media. In order to provide uniform air distribution within the cell, thereby ensuring longer media life and high odor removal efficiency, we would recommend reconfiguring the biofilter to have a surface loading rate of at least 5 CFM/SF and an EBCT of 60-90 seconds. The current air distribution system is constructed of HDPE and has multiple broken pipes near the biofilter wall. We would recommend locating the air header on the concrete slab inside the biofilter. This will reduce costs by eliminating buried piping while allowing the air header to be sized appropriately. The existing air header is a 24" pipe. The velocities in this pipe are currently approximately 1500 ft/minute. We would recommend a maximum velocity in the air header of approximately 1200 ft/minute to ensure more uniform air distribution which would require a 30" pipe header. The air distribution laterals will need to be replaced due to the failure of the existing pipes, and the spacing will be reduced to improve air distribution. The overall configuration of the media in the cell will need to be modified to provide more uniform air distribution while minimizing the potential for settlement and excess media. Improvements to the cell include raising the wall adjacent to the air header to match the wall height adjacent to the building and installing portable concrete barriers as "knee walls" along two sides of the cell. See Figure A-4 for a conceptual biofilter layout.

2.4.2 Solids Handling Biofilter

As discussed above, the Solids Handling biofilter serves to treat air from the centrifuge, sludge loading bay, aerobic digesters and the raw sewage pump station wet wells. The recommended flow rate to the biofilter is 8400 CFM. Due to the condition of the existing media, we would recommend replacing all of the biofilter media. In order to provide uniform air distribution within the cell, thereby ensuring longer media life and high odor removal efficiency, we would recommend reconfiguring the biofilter to have a surface loading rate of at least 5 CFM/SF and an EBCT of 60-90 seconds. The current air distribution system is constructed of HDPE and has multiple broken pipes near the biofilter wall, and the buried foul air distribution piping is allowing water to leak back into the building. We would recommend locating the air header on the concrete slab inside the biofilter. This will reduce costs by eliminating buried piping while allowing the air header to be sized appropriately. The existing air header is a 24" pipe. The velocities in this pipe are currently approximately 1500 ft/minute. We would recommend a maximum velocity in the air header of approximately 1200 ft/minute to ensure more uniform air distribution which would require a 36" pipe header. The air distribution laterals will need to be replaced due to the failure of the existing pipes, and the spacing will be reduced to improve air distribution. The overall configuration of the media in the cell will need to be reconfigured to provide more uniform air distribution while minimizing the potential for settlement and excess media. Improvements to the cell include raising the wall adjacent to the air header to match the wall height adjacent to the building and installing portable concrete barriers as "knee walls" along two sides of the cell. See Figure A-4 for a conceptual biofilter layout.

2.4.3 Filter Media

2.4.3.1 Inorganic Media

The existing river rock mixture utilized as the primary layer of filter media contains a large percentage of limestone cobbles. This material is highly susceptible to breaking down when exposed to the sulfuric acid present in the biofilter leachate. As these rocks breakdown fines can create a cement-like paste that can block air flow through the filter. The use of limestone as a filter media should be avoided. The recommended inorganic media for the facility would be lava rock or scoria. Lava rock is now commonly used as inorganic media due to its relatively light weight, natural pores that support water retention and microbial growth, and acid resistance. A sample media specification is attached for reference in Appendix B.

2.4.3.2 Organic Media

The upper layer of the existing filter media consists of hardwood mulch. Much of the existing media has composted which can lead to the buildup of fines in the filter bed impede the air flow. Average life expectancy for hardwood media is 2-3 years. The recommended organic media would be western pine/fir bark nuggets. This media has been used successfully in biofilters across the country for the last decade. The large bark nuggets break down at a very slow rate while still providing a substrate that promotes microbial growth. The average life expectancy for the bark media is 8-10 years. A sample media specification is attached for reference in Appendix B.

2.4.4 Corrosion Protection

The leachate from the biofilters will be acidic. The current biofilters have concrete walls and floor slabs that would be subject to corrosion. The rate of corrosion will be directly linked to the concentration of H2S in the foul air stream. Since the plant was not in operation when the site visit was performed, the exact loading rates are unknown at this time. However, there will likely be sufficient H2S loading to lower the pH of the leachate to 2 or lower at times. Therefore, we would recommend providing corrosion protection for the concrete surfaces in the biofilter. Common protection methods include coatings or liners. Either method could be used in this application. Coatings tend to have a higher capital cost while long term maintenance costs are low. There is also a risk of premature coating failure due to poor surface preparation and/or improper application. Liners are typically less expensive to install, but they are typically replaced when the media is replaced (at least the portion that is exposed).

2.4.5 Engineered Media Biofilter

Another option to provide odor control for the Pretreatment and Solids Handling facilities would be an engineered media biofilter. Engineered media biofilters utilize proprietary media designed to promote microbial growth. Engineered media manufacturers typically provide a guaranteed media life and will also guarantee media performance for specified inlet air constituents. However, the engineered media system capital costs are typically higher than the traditional biofilter design described above. One of the most commonly used manufacturers, Biorem, was contacted to provide a system design and cost estimate to replace/rehabilitate each biofilter. Information received from Biorem is provided in Appendix C.

While most of the improvements needed to the remainder of the foul air collection and conveyance systems would be the same for the traditional and engineered media biofilters, the engineered media biofilter option would require the following additional improvements:

- The engineered media biofilter would require four 6-ft tall walls to contain the media. While the traditional design concept would extend the existing knee wall to a 6-ft height, the installation of two additional walls along the perimeter of the cell would be necessary.
- The engineered media biofilter would include a humidification chamber on the discharge side of the foul air fan to attempt to increase the humidity of the foul air stream in addition to the surface irrigation system. These systems would include a housing, synthetic media, recirculation pump, and piping. Additional design effort would be required to determine the appropriate location, extend water and power supply, etc.
- The engineered biofilter requires the use of an air plenum floor to distribute the air under the media and provide support for the media bed. These modular air plenum floor systems do provide more even air distribution, but do have a higher capital cost.

Table 2-3 Engineered Media Biofilter Characteristics

PARAMETER	PRETREATMENT	SOLIDS HANDLING
Air Flow (CFM)	4,700	8,400
Approximate Media Bed Footprint (ft)	25 by 25	25 by 40
EBCT (sec)	30	30
Pressure Loss Through Media Bed (in H_2O)	6	6

2.5 BIOFILTER IRRIGATION

The existing biofilters use impact rotors to provide surface irrigation to the biofilter cells. While a detailed inspection of the irrigation system was not performed, the existing irrigation system concept is valid. Surface rotors spaced to provide head to head coverage will provide adequate irrigation. The key will be to ensure uniform coverage. If there are areas of the biofilter that are too dry or too wet, this will result in poor odor removal efficiency. It is recommended that the existing system be evaluated to ensure that the irrigation heads are functional, all pipes are still intact and not leaking and that the control systems are functional. Simple controls that allow for setting daily watering intervals are all that will be necessary.

3.0 RECOMMENDATIONS

3.1 RECOMMENDED IMPROVEMENTS FOR ODOR MITIGATION WITH BIOFILTERS

The following section summarize the recommended repairs and improvements to the air quality control facilities at LSWRF should the District choose to proceed with biofilters as their preferred method for odor control. The section also includes a budgetary cost for each item.

3.1.1 PRETREATMENT BIOFILTER

The following improvements and repairs are recommended for the Pretreatment biofilter system:

Table 3-1 Pretreatment Biofilter System Recommended Improvements

RECOMMENDED REPAIR/IMPROVEMENT	PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST	COMMENTS
Foul Air Conveyance		
Interior Intake Duct Replacement, Exterior Discharge Duct Replacement (building to biofilter only), Flexible Connections at Fan, FRP Trench Covers	$80,000	
Foul Air Fan Repairs	$6,000	Budgetary “Place-holder” only
Biofilter Cell		
New air header, media, geonet, wall extension, portable concrete barriers, HDPE liner	$207,000	Estimate includes HDPE Liner. Spray applied coating adds $50,000
Total:	**$293,000**	**Includes 30% Contingency**

The following improvements and repairs are recommended for the Pretreatment biofilter system if an *engineered media biofilter* is used:

Table 3-2 Pretreatment Biofilter System Engineered Media Option

RECOMMENDED REPAIR/IMPROVEMENT	PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST	COMMENTS
Foul Air Conveyance		
Interior Intake Duct Replacement, Exterior Discharge Duct Replacement	$80,000	

(building to biofilter only), Flexible Connections at Fan		
Foul Air Fan Repairs	$6,000	Budgetary "Place-holder" only
Biofilter Cell		
New air plenum, media, wall extensions, portable concrete barriers, HDPE liner	$421,000	Estimate includes HDPE Liner. Spray applied coating adds $45,000
Total:	**$507,000**	**Includes 30% Contingency**

3.1.2 SOLIDS HANDLING BIOFILTER

The following improvements and repairs are recommended for the Solids Handling biofilter system:

Table 3-3 Solids Handling Biofilter System Recommended Improvements

RECOMMENDED REPAIR/IMPROVEMENT	PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST	COMMENTS
Foul Air Conveyance		
Interior Intake Duct Replacement, Exterior Discharge Duct Replacement (building to biofilter only), Limited Buried Foul Air Pipe Replacement, Flexible Connections at Fan	$46,000	
Replace Fan – fan, AFD, equipment pad & wiring	$78,000	8,400 CFM fan
Biofilter Cell		
New air header, media, geonet, wall extension, portable concrete barriers, HDPE liner	$323,000	Estimate includes HDPE Liner. Spray applied coating adds $50,000
Total:	**$447,000**	**Includes 30% Contingency**

The following improvements and repairs are recommended for the Solids Handling biofilter system if an *engineered media biofilter* is used:

Table 3-4 Solids Handling Biofilter System Engineered Media Option

RECOMMENDED REPAIR/IMPROVEMENT	PRELIMINARY OPINION OF PROBABLE CONSTRUCTION COST	COMMENTS
Foul Air Conveyance		
Interior Intake Duct Replacement, Exterior Discharge Duct Replacement (building to biofilter only), Flexible Connections at Fan	$46,000	
Foul Air Fan Repairs	$78,000	8,400 CFM fan
Biofilter Cell		
New air plenum, media, wall extensions, portable concrete barriers, HDPE liner	$575,000	Estimate includes HDPE Liner. Spray applied coating adds $45,000
Total:	**$699,000**	**Includes 30% Contingency**

3.2 ALTERNATIVE ODOR TREATMENT TECHNOLOGIES

Review of the existing biofilter systems has noted extensive improvements required to bring them into working operation. Due to the significant cost of this work, an opportunity is available to transition these systems to an alternative odor treatment technology. This would allow for systems which provide the District with more preferred operation and maintenance characteristics. The following provides a summary of potential treatment technologies, including distinguishing features of each system.

3.2.1 Wet Scrubbers

In packed-tower wet scrubbers, foul air passes through a bed of plastic media, where it contacts a scrubbing liquid flowing downward through the bed. The scrubbing liquid collects in a sump below the packing and is recirculated up to a nozzle or tray distributor located above the packing. Wet, or Chemical, scrubbers utilize pH-controlled absorption and chemical oxidation to remove odorous compounds from an airstream. Chemical scrubbers can be vertically oriented with a single stage of media or they can have a horizontal low-profile arrangement with multiple stages of media. Figure 3-1 provides a photo of a typical chemical scrubber system.

Low pH scrubbing solutions are typically used to remove ammonia and amines, and high pH solutions are normally used for H_2S. For H_2S removal applications the most common scrubbing solution is sodium hydroxide (caustic) and sodium hypochlorite (bleach). Fresh chemical is automatically added through metering pumps controlled by pH and oxidation reduction potential

(ORP) probes, which vary the chemical feed to meet fluctuations in the inlet concentrations. To prevent solids accumulation in the recirculated liquid, a constant supply of makeup water is added to provide continuous overflow of the sump.

Figure 3-1 Typical Wet Scrubber

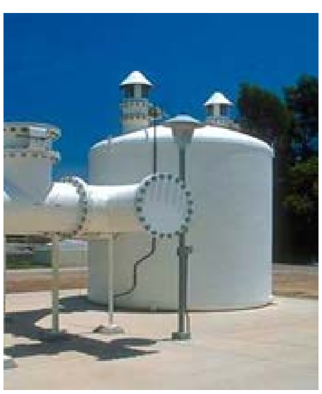
Wet scrubbers are sized for a face velocity of about 500 feet per minute (fpm), which results in a relatively small system footprint. These units can be installed outdoors with heat tracing for freeze protection in cold climates. The major advantages of wet scrubbers are their smaller areas needs and efficiency of removal. The primary disadvantages associated with these systems are handling of hazardous chemicals, complexity of operation, and level of required maintenance.

3.2.2 Activated Carbon

Activated carbon systems remove pollutants through surface adhesion on the carbon media. Carbon has a highly porous structure providing a very large surface area for contact. Deep bed carbon systems typically consist of a stainless steel or fiberglass vessel containing a bed of granular activated carbon through which the odorous air is discharged, as illustrated in Figure 3-2.

Carbon systems are sized for face velocities of 50 to 60 fpm and typically incorporate a media depth of 3 feet. The lower face velocity of carbon units means that, for the same airflow rate, they require larger vessels than wet (chemical) scrubbers. However, carbon units do not have chemical storage tanks and the area requirements can be further reduced by using dual stage units with stacked beds or radial flow units. The result is that carbon systems may not take up any more space than a similar capacity wet scrubber. There are several types of activated carbon media that have been used in the past, but currently the two main choices are VOC carbon or high H_2S capacity carbon.

Figure 3-2 Typical Activated Carbon Tower



VOC carbon media has been used in numerous wastewater applications because it will remove a wide range of odorous compounds. VOC carbon has a relatively low H_2S capacity, but it can be employed for treating aeration basins or as a polishing stage for biotrickling filters where residual H_2S is expected to be low.

High capacity media has a high H_2S capacity combined with excellent VOC reduction, but it has a higher cost than VOC carbon. The media is not impregnated, so it does not have some of the drawbacks associated with caustic impregnated carbons such as a low ignition temperature and handling concerns. The high surface area of the media greatly enhances its ability to remove a wide range of other odorous compounds. The H_2S capacity is 0.30 grams per cubic centimeter or about 55 percent by weight. When the media becomes depleted it is replaced with new media, but with no chemical impregnant, it is safer to load and remove. There are several vendors of high capacity carbon in the market, so competition is available.

The major advantages of activated carbon units are their relatively small footprint, efficiency of removal, and ease of operation. The main disadvantages are frequent and costly media replacement with high odor loads and assessing media depletion.

3.2.3 Biofilters

Biofiltration is a biological process using soil, compost, pine bark, lava rock, or other media as a substrate for microbes that remove odorous contaminants from an air stream as it travels through the media. Sufficient residence time must be provided for microbes to accomplish effective contaminant treatment, thereby requiring biofilters to use a low air velocity. For H_2S removal, typical residence times range from 30 to 60 seconds. Longer residence times may be necessary for airstreams containing high concentrations. Because the biodegradability of compounds differs, some compounds require several minutes of residence time for effective removal. Figure 3-3 shows a representative biofilter unit.

Figure 3-3 Representative Biofilter Unit

The key elements in biofilter design are media type, air distribution, and moisture content. Improper media can compact or become too soggy and lose its porosity quickly, whereas a properly formulated media will retain its structure over several years. Media porosity is also important to minimize head loss across the bed. To maintain reasonable pressure losses, maximum bed depths are typically 3 to 5 feet, yielding face velocities from 2 fpm to 8 fpm. The low velocity means biofilters have a large footprint. Biofilter media degrades through use and eventually must be replaced. The life cycle is dependent on contaminant concentration and the type of media used, ranging from 2 to 10 years.

Good air distribution through the biofilter media is an essential element of biofilter design. If air distribution is uneven, treatment will be inconsistent and channels can develop, allowing air to escape untreated. Early biofilter designs used a low cost network of perforated pipe embedded in gravel, but many of these systems have proved unreliable. Recent improved designs use a prefabricated plenum type air distribution system that provides even airflow with a minimum of pressure loss and at the same time allows good drainage. The manufactured air distribution systems are more costly than the simpler systems employed in early designs, but are necessary for reliable performance.

Another key parameter influencing the effectiveness of biofilters is moisture content. Biofilters must operate at a moisture content consistent with the requirements of microbial life, typically in the 40 to 60 percent range. Proper moisture content also prevents media drying and cracking, which allows the escape of untreated odors. Properly designed biofilters employ some means of adding moisture, either to the airstream, to the media internally, or to the top surface of the media.

Due to their larger size and labor-intensive construction, biofilters can cost significantly more to build than wet scrubbers or activated carbon units. However, the higher initial costs are offset by lower operational costs. The main advantages of biofilters are ease of operation, long media life, and effective treatment of reduced sulfur compounds and VOCs. The disadvantages are large footprint and, with uncovered units, an air discharges that are spread over a large area making efficiency measurements difficult.

3.2.4 Biotrickling Filters

Biotrickling filter (BTF) treatment is another type of biological odor control. BTFs are smaller than biofilters, and are well suited to treating high strength H_2S. Generally, these systems use some type of inert plastic media to accomplish effective removal of very high levels of H_2S. Foul air is introduced at the bottom of the media and fresh water or recycled sump liquid is sprayed over the top of the media. The liquid flows downward through the media and provides a moist environment that encourages microbial growth. An example of Biotrickling filter is shown in Figure 3-4.

Figure 3-4 Representative Biotrickling Filter

For H_2S treatment the microbes are chiefly *Thiobacillus*, which remove H_2S from the air as it passes through the media. Makeup water serves to flush the metabolic byproduct of sulfuric acid from the system. At wastewater treatment plants, it is possible that reclaimed water may be used to supply sufficient nutrients for the microbes. For collection system applications, potable water is used and supplemental nutrients are required to support the bacteria.

Most BTF systems employ high-density media composed of acid-resistant polymer material, which is resistant to plugging. Vendors typically guarantee the media life for 5-10 years, but most of their installations have not been operating for that long, so their media life predictions are only estimates. When replacement is needed, the old media is simply removed and new media added. Some systems use once through water, while others use a recycle pump to return the sump liquid to a nozzle at the top of the tower. In either case, the objective is to maintain the pH around 1.5.

BTFs are capable of treating much higher H_2S concentrations than biofilters in a smaller footprint. The residence time is typically 8-15 seconds versus 30-90 seconds for biofilters. In addition, BTFs can be made taller, so footprint is further reduced. However, BTFs only remove H_2S, so some type of polishing is required and a second stage of activated carbon has been used for most installations, which doubles the footprint. The main advantages of BTFs are long media life and efficient treatment of high H_2S. Disadvantages are their inability to effectively remove other odorous compounds requiring some type of polishing.

3.2.5 Neutralox

Neutralox is a relatively new treatment technology which utilizes ultraviolet radiation and a catalyst material to treat a range of odor causing compounds. The system was designed and first introduced in Germany in the late 1990's. It has since been introduced to the United States market through a licensing agreement.

Treatment of the foul air stream begins with removal of excess moisture through a prefilter. The air then enters a photoionization chamber where ultraviolet light is used to oxidize and break down the odor causing compounds. The air then enters a final chamber filled with a catalyst material, such as carbon, where remnant odor compounds are adsorbed onto the media, and ozone created by the ultraviolet light is removed. The air is then exhausted to atmosphere.

With the use of the Photoionization step, the quantity of catalysis material is reduced to approximately 10-15% of what is required with a traditional carbon filtration system. Like carbon filtration, the catalyst material requires changing as the material is exhausted. While the time between changes varies depending on the inlet concentration of the odor compounds, typical design media life is 8,760 hours, or one year of operation. Routine replacement of the bulbs is also required after approximately 12,000 hours of use.

The treatment capacity of a self-contained Neutralox unit is typically limited to 1,000 – 3,000 cfm, and includes an integral exhaust fan. For foul air streams in excess of 3,000 cfm, larger single Neutralox units can be supplied which require separate, externally mounted fans. For larger volumes of air, multiple units are mounted in parallel until the desired system capacity is met.

The major advantages of a Neutralox system are the small footprint, efficiency of removal, and ease of operation. The main disadvantages are frequent and costly media replacement of the catalyst material, and bulbs. Also, the treatment technology is relatively new, with limited installation available to prove the effectiveness of the system as a reliable treatment technology.

3.2.6 Alternative Treatment Technology Summary

The following provides a summary of potential treatment technologies, including distinguishing features of each system.

Table 3-5 Alternative Treatment Technology Summary

CRITERIA	WET SCRUBBER	ACTIVATED CARBON	BIOFILTER	BIOTRICKLING FILTER	NEUTRALOX
Footprint	-Smallest in size	-Relatively small -Size reduced by using dual beds	-Largest in size	-Smaller than biofilter	-Similar to wet scrubber
Ease of Operation	-Very complex operation, numerous pumps and controls	-Simplest operation -Media replacement required	-Easy to maintain if properly designed with long life media -Operators are familiar with this technology	-Less complex than wet scrubber -Carbon polisher requires attention	-Simple operation -Media, prefilter and UV source replacement required
Chemical Handling	-Hazardous chemicals (caustic and hypochlorite) used	-No chemicals	-No chemicals	-No chemicals	-No chemicals
Reliability	-Reliability affected by maintenance	-High reliability with fresh media -Out of service more often during media replacement	-High reliability -Not suited to intermittent use	-High reliability -Not suited to intermittent use	-High reliability according to manufacturer
Performance	-High efficiency -Chemical increased to meet demand -Some residual chemical odor	-High efficiency -Provides lowest outlet odor	-High efficiency -Some residual organic odor	-High efficiency -Polishing required to treat VOCS	-High efficiency
Compounds Treated	-Both H_2S and VOCS	-Both H_2S and VOCS	-Both H_2S and VOCS	-H_2S only	-Both H_2S and VOCS
Cost	-Low capital cost, but high operating costs	-Low capital cost, but high operating costs for high loads	-Moderate capital cost, but low operating costs	-Moderate capital cost, but low operating costs	-Low capital cost, but high operating costs for high loads

3.3 RECOMMENDED NEXT STEPS

The following items should be investigated further prior to finalizing any repair, rehabilitation, or alternative treatment plans:

- The existing buried foul air piping should be inspected. Water intrusion into the piping was observed in the Solids Handling foul air piping. A simple CCTV inspection should be able to identify any defects in the existing system that will require repairs.
- The required ventilation rate for each system should be confirmed with the code analysis being performed under a separate contract. The ventilation rates will need to be finalized prior to proceeding with any further analysis and design of the rehabilitation of the biofilters and associated equipment, or alternative odor mitigation systems.
- Investigate the ability to modify building ventilation schemes to minimize the volume of air required for treatment.
- An analysis of the influent gravity sewer will need to be confirmed to finalize the ventilation rate for the raw sewage pump station wet well. The presence of any corrosion protective coatings or concrete admixtures in the wet well will need to be determined.
- Recommended ventilation rates and connection points need to be confirmed with the screen and centrifuge manufacturers.
- The existing fan in the pretreatment building should be inspected by a manufacturer's representative to assess the condition of the fan. It is likely than some fan components will need to be replaced if the fan is reused.
- Collect air samples and characterize odors to determine the suitability of potential alternative treatment systems.
- Evaluate enhanced dispersion and other treatment technologies. Consider pilot testing at other District reclamation facilities with similar collection system characteristic to assess system performance.

APPENDIX A: FIGURES

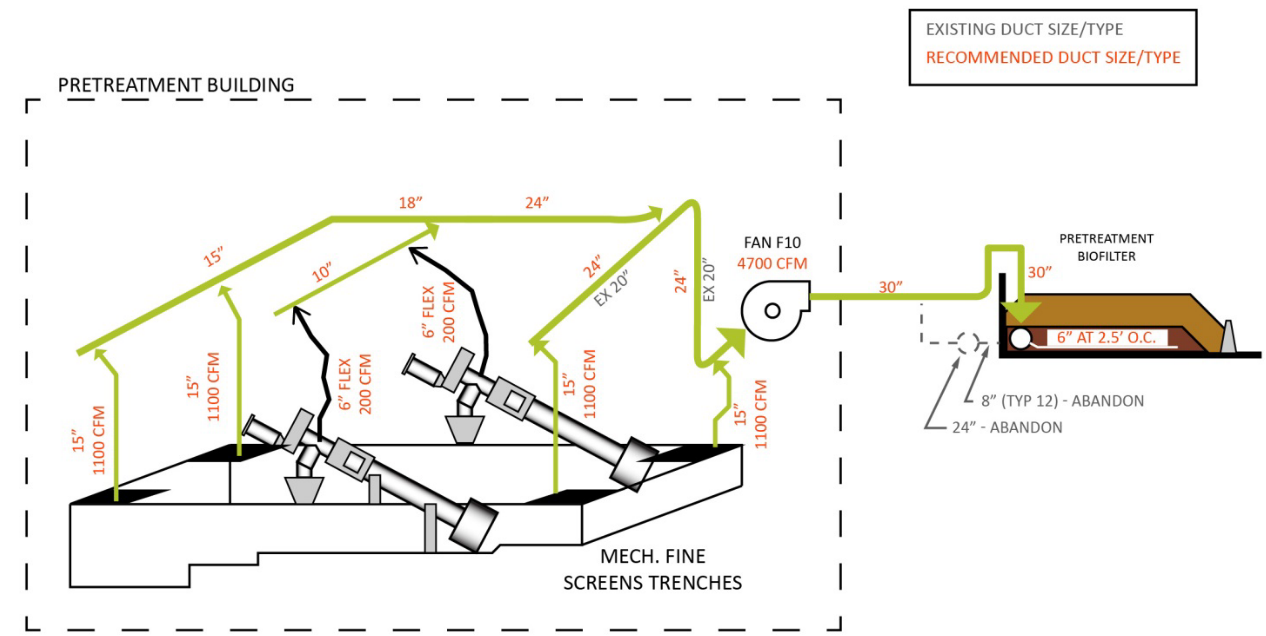


Figure A-1 Pretreatment Odor Control System Diagram

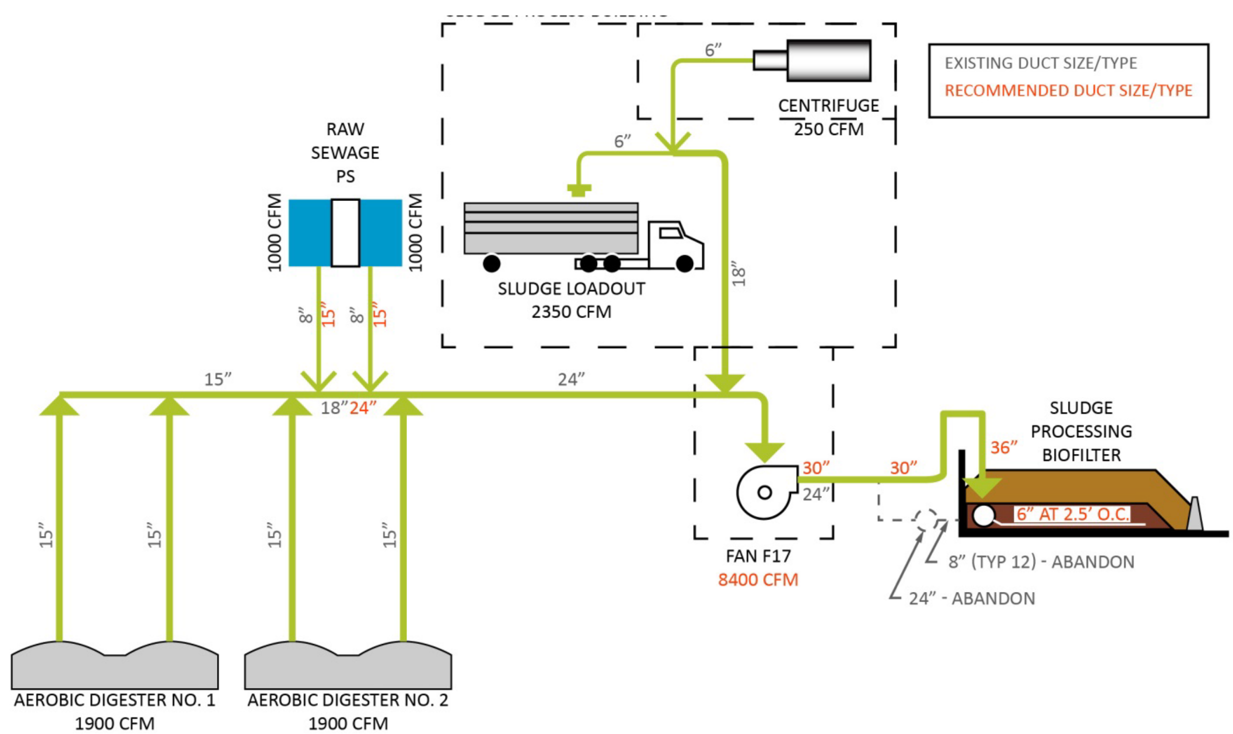
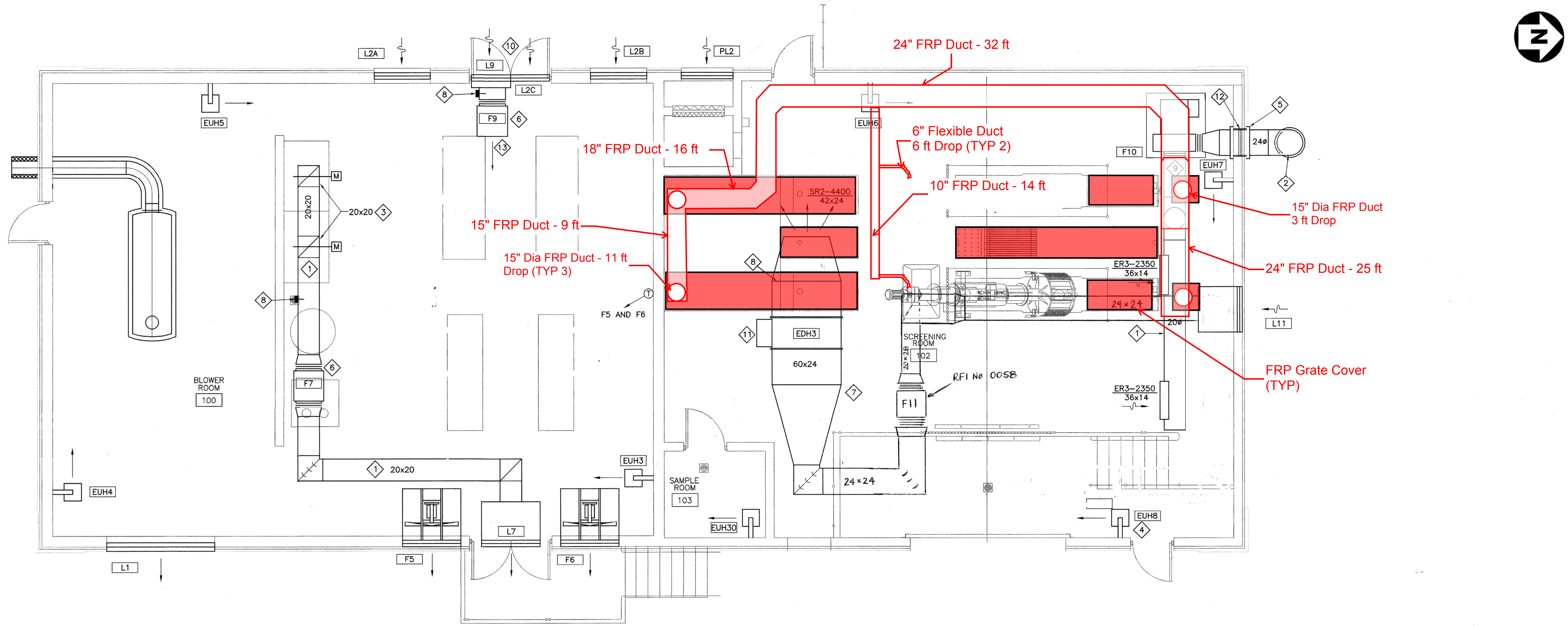


Figure A-2 Solids Handling Odor Control System Diagram



CODED NOTES

1. BOTTOM OF DUCT AT 9'-0" A.F.F.
2. DUCT TURNS DOWN TO CONNECT TO UNDERGROUND SUPPLY MANIFOLD FOR BIOFILTER. PROVIDE DUCT FLANGE FOR CONNECTION TO HDPE SUPPLY MANIFOLD. SEE SHEET 027 FOR EXACT LOCATION OF BIOFILTER SUPPLY MANIFOLD.
3. EXHAUST DUCTS DOWN TO CONNECTION AT CASING OF AIR COMPRESSOR. TRANSITION IN VERTICAL TO REQUIRED CONNECTION SIZE. PROVIDE MOTORIZED DAMPER IN EACH BRANCH.
4. MOUNT EUH8 AT 10'-0" ABOVE FLOOR LEVEL OF RECESSED SLAB AREA.
5. PROVIDE STAINLESS STEEL ANGLE RING, 2"x2"x ¼", AT AT BOTH SIDES OF WALL PENETRATION.
6. SUSPEND FAN FROM ROOF STRUCTURE WITH STAINLESS STEEL HANGER ROD AND RESTRAINED SPRING VIBRATION ISOLATION.
7. TRANSITION DUCT TO CONNECTION SIZE REQUIRED AT DUCT HEATER.
8. AIRFLOW SWITCH MOUNTED IN DUCT
9. PROVIDE 40 INCHES MINIMUM STRAIGHT DUCT BETWEEN ELBOW AND INLET OF FAN.
10. INSTALL LOUVERS IN TRANSOM PANEL ABOVE DOOR. COORDINATE WITH STRUCTURAL DETAILS OF TRANSOM.
11. EXPLOSION PROOF NEMA 7 CONTROL PANEL
12. SEAL DUCTWORK THRU WALL WITH SLEEVE AND MECHANICAL LINK SLEEVE SEAL.
13. COVER FAN DISCHARGE OPENING WITH 1/2"x1/2" ALUMINUM BIRDSCREEN.

PLAN NOTES

1. PROVIDE 8" CONCRETE HOUSEKEEPING PAD FOR FAN F10
2. DUCTWORK CONNECTED TO ODOR CONTROL FAN, F10 SHALL BE PVC, OR FRP CONSTRUCTION, PER THE SPECIFICATIONS.
3. F5, F6, AND L7 ARE INSTALLED IN ROOF DORMER. SEE ARCHITECTURAL PLANS
4. MOUNT UNIT HEATERS WITH BOTTOM AT 8'-0" A.F.F UNLESS NOTED OTHERWISE.
5. PROVIDE ALUMINUM DUCTWORK TO CONNECT STAND-BY GENERATOR RADIATOR OUTLET COLLAR TO EXHAUST LOUVER L1
6. SUSPEND ELECTRIC DUCT HEATER EDH3 FROM ROOF STRUCTURE WITH HANGER ROD.
7. PRETREATMENT BUILDING IS A CLASS 1, DIV 2 EXPLOSION HAZARD AREA. MOTORS AND ELECTRIC HEATING COILS PROVIDED IN HVAC EQUIPMENT MUST BE EXPLOSION PROOF.
8. COMPLY WITH SPECIFICATION REQUIREMENTS FOR CORROSIVE ATMOSPHERE DUCT HANGER MATERIALS FOR DUCTWORK CONNECTED TO FAN F11.

NO.	REVISIONS	DATE	BY	CHK.

Burgess & Niple, Inc. COLUMBUS, OHIO

BURGESS & NIPLE

DELAWARE COUNTY, OHIO
LOWER SCIOTO WATER RECLAMATION FACILITY

JOB NO.	PR35649
DESIGNED BY:	CDN
DRAWN BY:	CDN
CHECKED BY:	ACV
APPROVED BY:	RBD
DATE:	MARCH 2007

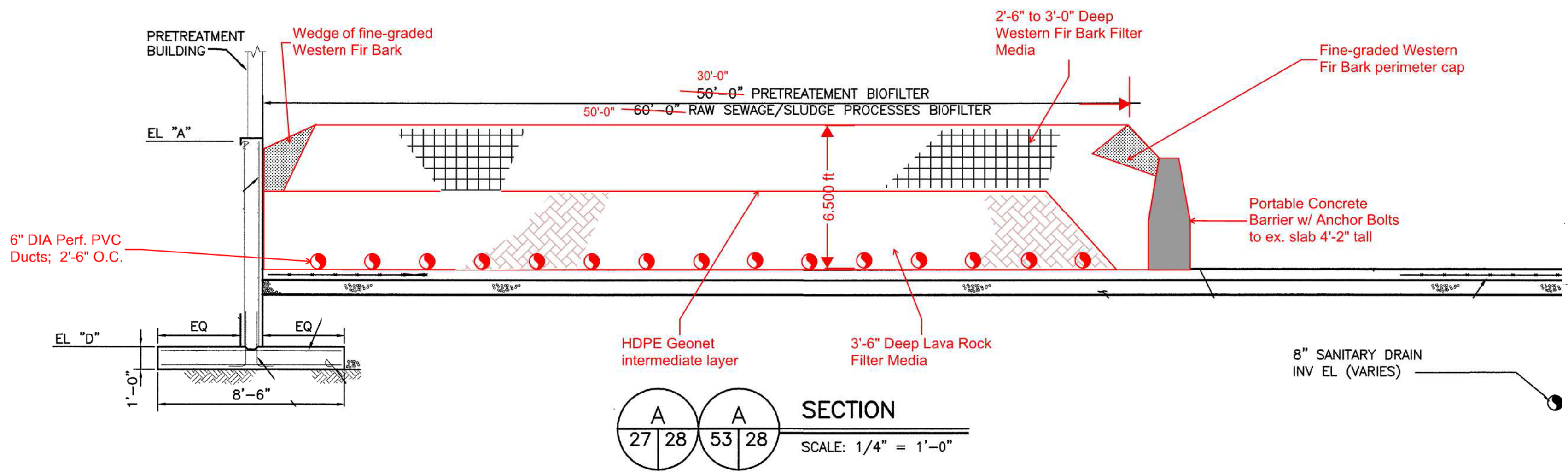
PRETREATMENT BLOWER BUILDING HEATING AND VENTILATION PLAN

SCALE: 1/4"=1'-0"

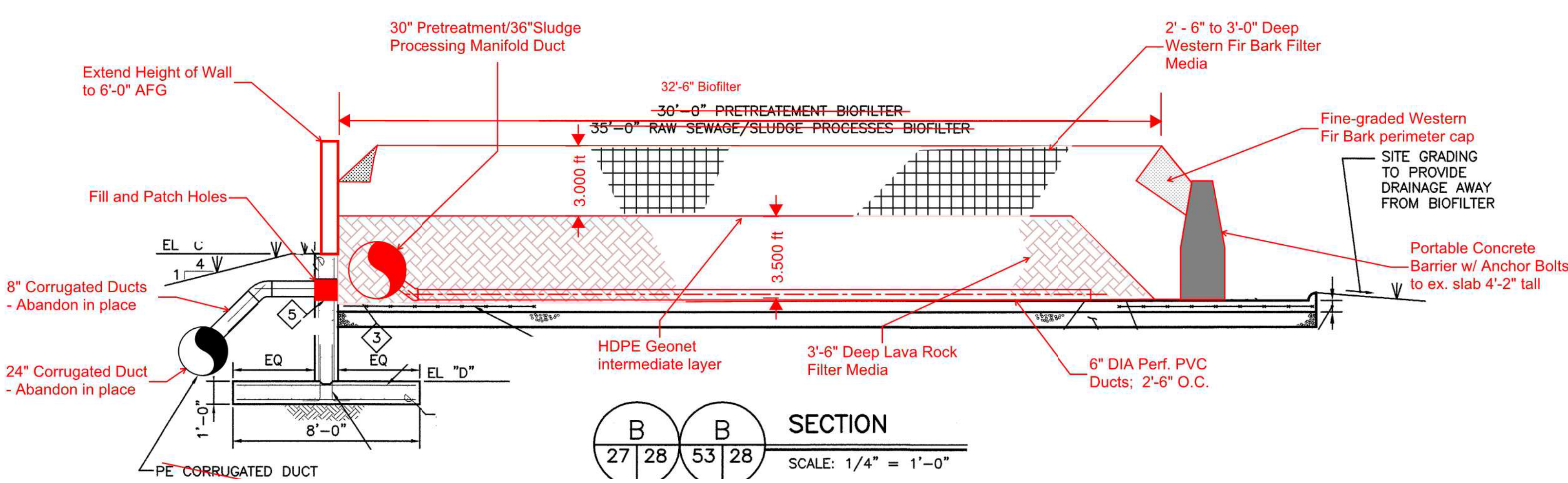
SHEET NO. 84 OF 131

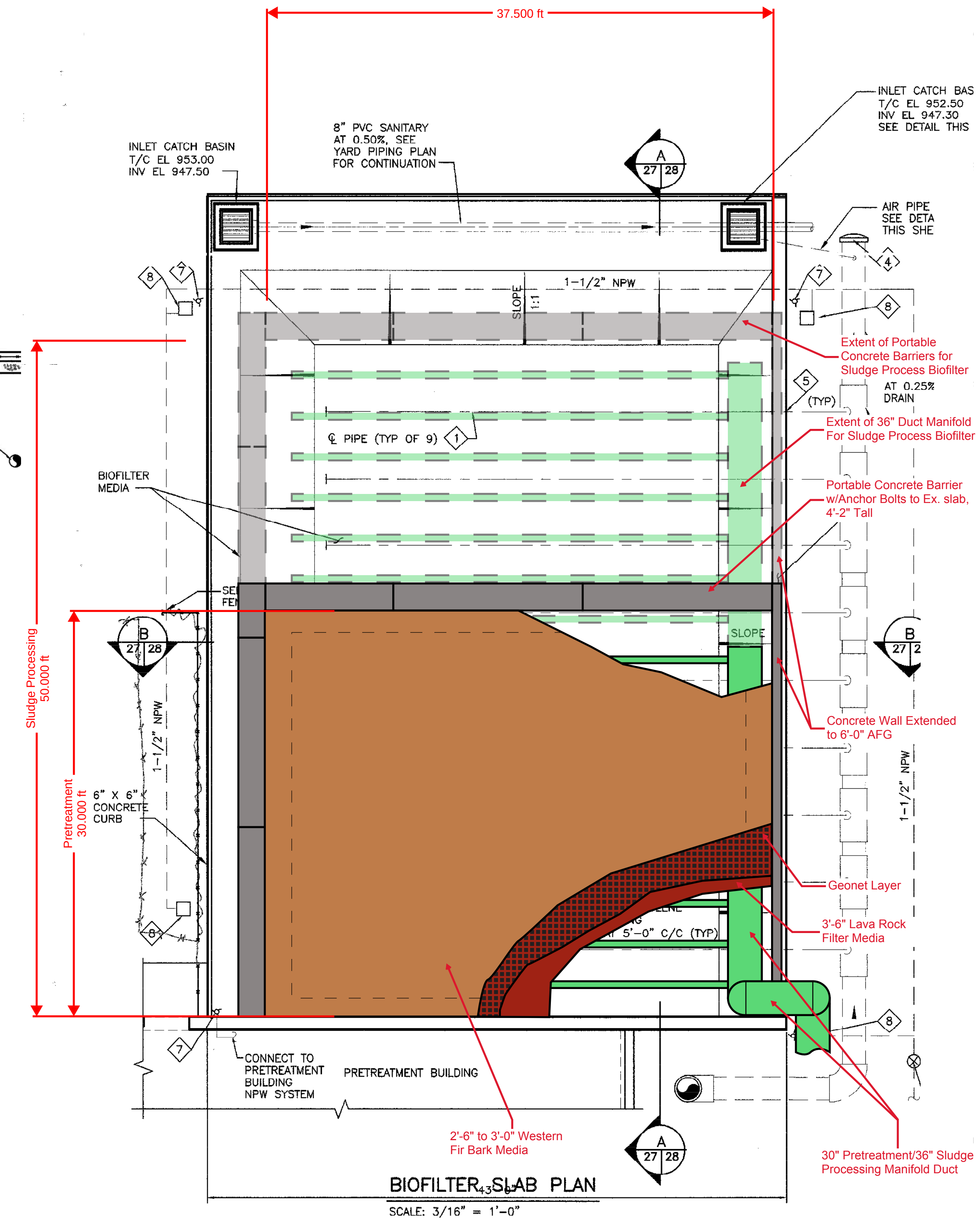
PLOTTED: 10/10/2007 4:08:10 PM

P:\PR35649\cadd\SHT084.dwg 9/28/2007 10:54:09 AM Corman, Mike



NOTE:
REFER TO CODED NOTES ON SHEET 28





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APPENDIX B: SAMPLE MEDIA SPECIFICATION

SECTION 13270

BIOFILTER ODOR CONTROL SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Furnish, install and test one biofilter odor control system to treat odorous air at the location indicated in the Contract Documents. The system shall be installed, complete and operable, in accordance with the Contract Documents. The equipment shall include but not be limited to structures, piping, control dampers, instrumentation, biofilter media, irrigation system, and other appurtenances necessary for a complete operable system.

1.05 SUBMITTALS

A. Biofilter Shop Drawings: The Contractor shall submit complete shop drawings of all the odor control systems specified in this section. The biofilter odor control equipment shop drawing submittals shall include a submittal for the following:

1. Fully dimensioned installation drawings for all major pieces of equipment.

2. Detailed catalog equipment cut sheets for all piping, valves, dampers and liner materials, and all mechanical and electrical equipment. Sizes, ratings, materials of construction and utility requirements shall be indicated on the cut sheets.

1. Dimensional drawings, support and anchoring details along with assembly and installation drawings including anchor bolt plans, parts nomenclature, material lists, outline dimensions and shipping weights.

2. Electrical data including all control and wiring diagrams. Electrical diagrams shall include, but not be limited to all power system wiring and grounding requirements for equipment.

3. Biofilter Media.

a. Material gradation reports shall be submitted for the lava rock media and bark biofilter media.

b. Lava rock media test reports for silicon dioxide percentage content in accordance with ASTM.

c. Samples: A one cubic foot material sample shall be submitted for the lava rock media and bark biofilter media for review. Materials will be reviewed against the requirements of this section. No Biofilter media shall be delivered to the site until an acceptable review disposition has been returned by Engineer. Engineer will use samples as a bench mark against materials delivered to the site. All materials not meeting the same gradation or other requirements as described herein, and to the opinion of Engineer, will be rejected and shall be replaced at Contractors expense.

PART 2 PRODUCTS

2.01 GENERAL

A. The Contractor shall provide two (2) biofilter odor control systems as shown on the Drawings, complete coatings/liners, biofilter media, irrigation systems and all other appurtenances for a complete system.

2.08 BIOFILTER MEDIA

A. The Contractor shall provide a biofilter media of the depth and composition specified herein and shown on the Drawings.

B. Organic Media.

1. The primary media shall consist of Douglas Fir nuggets and/or Ponderosa Pine Bark. The media shall be provided as a homogeneous mixture having a pH from 6-8. Bark fines shall be added to the perimeter only. Bark fines shall not be mixed into the virgin bark under any circumstance. Bark fines shall be applied around the perimeter of the walls as shown on the drawings. Bark fines shall be materials left over from the on-site bark screening operation.

2. Organic Media shall consist of fresh Douglas Fir and/or Ponderosa Pine bark chips. A minimum 90% by volume of the bark chips shall be 3 inches to 6 inches in the greatest di-

mension and 3/4 to 1-1/4 inches thick. Media thicker than 1-1/4 inches and 6 to 7 inches long is acceptable. Larger media is preferred. The bark shall be virgin uncomposted material screened and stored for less than 60 days before installation. Up to 5% of the Bark volume may be wood chips left over from the debarking process. Wood chips shall NOT be added to the bark under any circumstances. Up to 5% volume of the Bark Chips may be pieces less than or equal to 1.0 inch nominal diameter; however, most of these will be removed during onsite screening process. Wood chips shall have same size and shape requirements as the Bark. Similar high-density pine or fir bark may be used if approved by the Design Professional. Size distribution of the installed bark shall be uniform. Pockets or clusters of small bark (less than 1 inch) that constitute greater than 2% volume are not allowed unless specifically called out in drawings.

Debarking of product shall not have occurred between the cold weather months (October 1 to April 30).

a. The following suppliers are not "approved suppliers"; however, they typically stock material ("Large Bark") that meets the requirements of this sub section.

1. Mountain West, LLC
   4212 Hwy 191
   Rexburg, ID 83440
   1-888-686-2275

2. Sierra Pacific Industries
   PO Box 496028
   Redding, CA 96049-6028
   Chris Caldwell
   530-378-8257

C. Fine Biofilter Media: Screened bark fines shall be used for fine media in the biofilter. Screened fines shall remain on site for use in the biofilter 6 weeks after official startup. If sufficient bark screenings are not available, then Yard Waste Compost shall be used. Yard waste compost shall be the product of a thermophilic aerobic decomposition process. It shall be subjected to a minimum of 60 days of thermophilic conditions, and be adequately stabilized to be free of odors. Tub ground yard waste may be allowed if screened and cured such that it is no longer self-heating. The material shall be graded so it passes through a 3/8 inch mesh screen. Compost must have a pH of 6 to 8. The compost source shall be subject to review by the Design Professional. All compost shall be stabilized so that it is no longer self-heating. Bark fines and yard waste compost shall be friable and free of stones and objectionable debris and dirt of any kind.

D. Inorganic Media: The inorganic media shall consist of lava rock and shall be graded to maintain proper air distribution. Care shall be taken to prevent damage to the air plenum system, concrete coating and structures during the placement of the lava rock media.

1. The lava rock media shall consist of high silica volcanic scoria with a nominal diameter of 1 to 2 inches. The scoria rock shall be a minimum of 45% silica and be impervious to exposure to a 10% sulfuric or 20% muriatic acid solution. The scoria shall meet the following criteria. Quarry shall demonstrate historical testing data showing silica content or perform testing the dissolves the glass matrix and analyzes all silica in the scoria sample. Low silica scoria typical of the central and western Pacific regions is not allowed

   a. Specific Gravity (ASTM C 127) - 1.35 to 1.50 (Oven Dry Basis)

   b. Screening & Grading (ASTM C136)

   c. Silica Testing shall be in accordance with ASTM C25

3. The following suppliers are not "approved suppliers"; however, they typically stock material that meets the requirements of this sub section. The supplier must provide a chain of custody showing the latitude and longitude of the lava rock mine (+/- 4 miles).

   a. Red Dome, Inc.
      5865 West 200 South
      Fillmore, UT 84631
      (801) 615-5019

   b. Global Environmental Solutions
      Crater-Max™ Lava Rock,
      Yucaipa, CA
      (909) 797-1245

E. Geonet Barrier:

1. Manufacturers:

    a. SYNTECH TENDRAIN BF

    b. or approved equal.

2. The geonet barrier shall be an open mesh, tri-planar material (no woven fabrics attached) and shall serve as a boundary layer between the Organic and Inorganic media to prevent migration of particles. Bi-planar materials and materials with woven fabrics shall not be acceptable. The geonet barrier shall be placed where indicated and as shown on the Drawings prior to the addition of the biofilter media. The geonet core shall have a tri-planar structure and the following material properties at a minimum

Property	Test Method	Value
Resin Density	ASTM D 792 or D1505	0.94g/cm^2
Geonet Cross-Rib Spacing	Calibered	0.4 inch
Geonet Main-Rib Spacing	Calibered	0.5 inch
Unsupported Aperture Area	Calibered	0.3 inch (Max)
Carbon Black	ASTM D 4218	2 %
Thickness	ASTM D 5199	0.275 inches
Tensile Strength – MD	ASTM D 7179	1000 lb/ft
Roll Size Minimum Width		12 ft

PART 3 EXECUTION

3.01 INSTALLATION OF BIOFILTER

A. Installation of each biofilter shall be in full conformity with the Drawings and Specifications. Each piece of equipment shall be furnished and installed complete with all supports, electrical work, and appurtenances ready for operation. Excavation, pipe trenches, and backfilling and other earthwork shall be performed in accordance with the Contract Documents.

B. Inspection: Notify Owner at least 5 full working days in advance of installing and or testing the air plenum, lava rock media, first 18-inches of media, sprinkler system, and final 3 feet of media.

C. Biofilter Plenum Floor Installation:

1. The biofilter plenum floor shall be installed in accordance with the manufacturer’s instructions.

2. The biofilter plenum floor components shall not be modified in the field without written authorization from the manufacturer and prior approval from the Design Professional.

3. The biofilter plenum floor components shall fit together tightly with no gaps between panels. All floor supports shall maintain contact with the biofilter cell floor.

4. The biofilter plenum floor perimeter seal shall be installed around the full perimeter of each cell. The surface of both the plenum floor and adjacent concrete shall be cleaned prior to installation of the perimeter floor seal. The perimeter seal material shall be fastened to the plenum floor in a manner that will not block the perforations/openings in the plenum floor. The perimeter seal material shall be lapped a minimum of 6” at all splice joints.

D. The biofilter media shall be placed loose, with no mechanical compaction.

1. Organic media shall be screened 1 inch plus before installing in the biofilter.

    a. Screening shall be conducted on site to remove fine material from the media. Note that the Large bark volume settles approximately 10 to 25% during transport and fine material typically exceeds 5% of the volume of Clean bulk bark. These percentages are approximate and vary significantly depending on the tree size and pre-screening by supplier. Clarify these issues with supplier.

    b. Screening shall be performed using a portable variable speed trommel screen or equal.

    c. Screening shall by sufficiently slow to remove the 1 inch minus material from the bark shipments. Contractor shall demonstrate screening process for approval. The screening procedure approved during the demonstration shall be maintained for all screening, no exceptions. Final bark media shall have up to 1% volume of 1 inch nominal diameter.

Note: Slow screening shall be attained by adjusting the angle of the Trommel screen. Rotational speed of the screen shall be maintained at a speed that adequately screens the Bark media.

d. Bark that does not meet specifications will be rejected and rescreened. No exceptions.

e. Bulk storing of screened bark for 30 days is allowed if trommel screens are used for screening and a Telebelt is used to install media. Bulk media shall be stored on concrete, wood or plastic. Storage on gravel or dirt is not allowed unless approved by the Design Professional. Bark screened by approved non-trommel screen equipment can be stored for 15 days and must be inspected and approved for use by the design professional before installation.

f. The Design Professional shall be notified 7 days prior to the Bark screening and installation.

g. Composted wood or bark chips shall not be used.

h. Bark placement with rock slingers, conveyors, or other horizontal "throwing" type material movers is prohibited, no exceptions. Non-slinging slow conveyors such as a Telebelt are permitted if the system is operated at slow speeds and the discharge nozzle always discharges vertically.

i. Telebelt nozzle shall move constantly and the nozzle shall be 3 to 4 feet above the media during application.

   1. Media lifts shall be a maximum of 12 inches.

   2. Delivery belt speed shall be sufficiently slow as to not break bark. Contractor shall demonstrate delivery process for approval buy engineer. Hopper and belt speeds shall be maintained at settings approved during the contractor demonstration, no exceptions.

j. Installed bark depth shall be 42 inches. There are 6 inches of allowable settlement after 30 days. If settlement exceeds 6 inches then the contractor shall add media to attain a minimum media depth of 36 inches.

k. The Design Professional shall be notified 7 days prior to the Bark screening and installation.

2. Inorganic Media

a. Gradation

Sieve Size	Percentage Passing
2 ½”	100
2”	92 to 97
1 ½”	60 to 75
1”	5 to 10
¾”	0 to 2
½”	0

Percentage Voids ASTM C29- Greater than 40%

2. Lava Rock shall be screened using the same equipment used for screening bark. Different trommel screen speed may be required; however, the finished product shall meet the Screening & Grading criteria. Installation shall be identical to the bark requirements. Contractor shall perform a test to establish installation criteria. Installation shall be sufficiently slow to produce negligible breakage.

A. Performance testing of the biofilter shall be conducted in accordance with the requirements as specified following 30 days of continuous operation. Performance testing will not be allowed between November 1 and April 1.

Perform a minimum of 6 smoke tests on each biofilter in phases as follows:

1. Air distribution flooring after installation.
2. Lava Rock Media - 18 inches deep.
3. Lava Rock Media - 42 inches deep
4. Lava Rock Media - Final depth and before installation of Geonet and inbed irrigation.
5. Organic Biofilter Media - 1 foot depth
6. Organic Biofilter Media - Final depth

Smoke tests must be approved by Engineer prior to performing the next construction step. All tests shall be conducted in the presence of Engineer at wind speeds less than 8 mph. First four (4) smoke tests shall be performed at 3,500 cfm per cell. The remaining smoke test shall be at 5,000 cfm per cell. At least four (4) days notice shall be provided to the Design Professional prior to testing; however, scheduling, can be adjusted to comply with wind speed test restrictions. Media (both lava rock and bark biofilter media) shall be removed and replaced as required by the Design Professional and at no cost to the City to achieve proper airflow distribution. The smoke test on the biofilter media shall be conducted between fourteen (14) days of media placement and within forty five (45) days of planned biofilter startup under the design conditions specified herein. Smoke used for testing shall be non-colored and non-toxic. The contractor shall videotape the smoke test and provide a digital copy on DVD to the Design Professional

F. Unless otherwise specified, all equipment and materials shall be provided a protective coating in accordance with the Contract Documents.

++END OF SECTION++

APPENDIX C: BIOREM VENDOR SUPPLIED INFORMATION

Budgetary Proposal

Lower Scioto WRF Biofilters – Headworks

BIOREM Ref#: 18-4006

January 30, 2018

BIOREM

experience. integrity. performance.

Represented By:

Sullivan Environmental Technologies, Inc.

Wendell Smitley

1-614-395-7379

wendell@sullivanenvtec.com

Regional Sales Manager:

Dean Parker

585-455-0129

dparker@biorem.biz

LEADING INNOVATION IN BIO-ENGINEERED AIR CONTROL TECHNOLOGIES

Founded in 1991, BIOREM® is a global clean technology engineering company with one objective: engineer, design, manufacture and distribute the most innovative and effective biological-based emissions abatement technologies in the world.

As a leader in emissions abatement, our engineering teams have installed more than 1,200 projects worldwide. We specialize in tackling the exceptionally difficult problems of odour, volatile organic compounds (VOCs), and hazardous air pollutants, then engineering innovative solutions for the lowest life cycle cost of any technology.

BIOREM offers a lifetime commitment that our engineered systems will solve your air emissions and odour control problems. At the core of our business strategy is to be your trusted partner.

This means you can rely on BIOREM for any project, any size, anywhere and be certain you have the best available technology and support to solve your most difficult challenges.

Engineering the Difference

Superior physical, chemical and biological solutions that effectively and reliably control air emissions require advanced engineering knowledge and expertise. This is why all BIOREM teams are multidisciplinary units comprising biological, chemical, environmental and mechanical engineers and scientists.

BiofiltAIR - Concrete Biofilter

BiofiltAIR systems are for large airflows and particularly suited for dense urban environments. They can be integrated into the building envelope, or located underground, above ground or a combination of the two.

These systems can also be designed for forced draft or induced flow (positive or negative pressure) and are available with a wide range of instrumentation and controls.

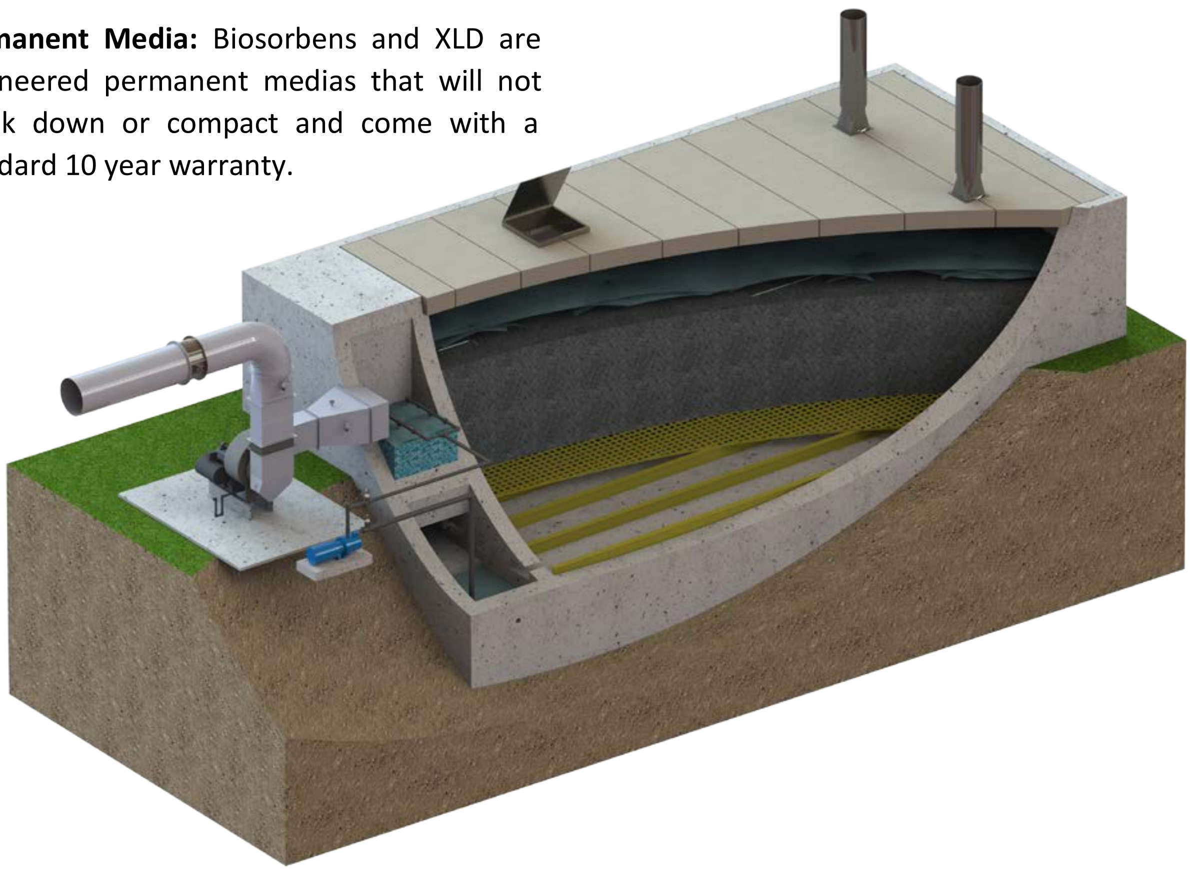
BiofiltAIR systems are aesthetically pleasing and can be integrated seamlessly with onsite weather stations and contino0us performance monitoring.

Custom: Units are built to the specific needs and requirements of each client to ensure guaranteed satisfaction.

Permanent Media: Biosorbens and XLD are engineered permanent medias that will not break down or compact and come with a standard 10 year warranty.

BIOREM is the only reliable solutions provider able to guarantee systems to meet a 1 OU odor requirement and has a proven track record to demonstrate this.

Our engineers have created the larges performance database for odor control and can work with clients to assist on forecasting operating scenarios for greenfield applications.



Revision History

Number	Description	Date	Author

Contents

Project Details

Table 1 - Inlet Foul Air Quality

Process Parameter	Value
Flow Rate	4,700 SCFM
Temperature	50 - 100 °F
Relative Humidity	>50% RH
Average H_2S Concentration	10 ppm (assumed)
Peak H_2S Concentration	20 ppm (assumed)
Organic Sulfur Compound Concentration	< 2 ppm (assumed)

Table 2: Overall System Configuration and Common Utilities

Design Parameter	Value
System Configuration	Site constructed biofilter
Water Supply Source	Potable preferred
Estimated Water Consumption	Approx. 300 GPD
Electrical Supply Required	460V / 3PH / 60Hz

Table 3: Biofilter Vessel Design

Design Parameter	Value
Number of Biofilter Vessels	1
Biofilter Vessel Dimensions	30 ft length : 20 ft width : 12 ft wall height
Number of Internal Treatment Stages	2: humidifier followed by biofilter
Humidifier Water Recirculation Rate	48 gpm
Humidifier Drain Water pH	5 - 8
Biofilter Drain Water pH	5 - 8

System Performance

A. When loaded under average conditions the biofiltration system will achieve at least 99 percent removal of H_2S for inlet concentration levels above 10 ppm. For inlet concentration levels less than 10 ppm, the outlet concentration levels shall be less than 0.1 ppm.

B. When loaded under average conditions the biofilter system shall provide at least 90 percent odor removal for inlet concentration levels between 6,000 and 15,000 OU. For inlet concentration levels less than 6,000, the outlet concentration levels shall be less than 600 OU. (Odor concentrations to be determined using ASTM-E679 with a 20 liter/minute odor panel presentation rate).

Warranties

A. The Manufacturer warrants that the biofilter media will not compact, degrade or decompose for a period of 10 years from the date of Substantial Completion, provided that the system is operated in accordance with the Manufacturer's printed Operation and Maintenance Manuals.

B. All mechanical components will be warranted free of manufacturing defects for a period of 12 months from Substantial Completion, or 18 months of shipment, whichever occurs first.

Scope of Supply

1. Concrete biofilter vessel structural design, supply and installation **by others**.
2. Biofilter media support flooring. Material of construction to be FRP grating and I-beams.
3. Humidification mass transfer packing, provided in boxes approximately 10 cubic feet in size.
4. Engineered biofilter media, provided in loose bulk .
5. (1) Butterfly damper for airflow isolation upstream of fan.
6. (1) Rectangular flexible transition piece on fan outlet, flange material of construction to be 304 stainless steel.
7. (1) 3 HP recirculation pump rated for 48 GPM at 100 ft head with a TEFC motor.
8. (1) Fan – **Provided by others**.
9. (1) Schedule 80 PVC manifold with spiral spray nozzles for optimized coverage of humidification media.
10. (1) Schedule 80 PVC manifold with matched precipitation rate nozzles for optimized coverage of biofilter media.
11. (1) Control Panel:
    i. NEMA 4X 304 stainless steel enclosure with pedestal legs.
    ii. Door mounted fused disconnect.
    iii. VFD and Hand/Off/Auto selector switch for exhaust fan.

iv. Motor starter and Hand/Off/Auto selector switch for recirculation pump.
v. Status lights for fan and recirculation pump.
vi. Recirculation low flow alarm light.
vii. Alarm reset push button.
viii. Dry contacts for transmitting signals to a remote location.

12. (1) Waterbox:
    i. NEMA 4X 304 stainless steel pre-plumbed enclosure with pedestal legs.
    ii. (1) Flow indicator/switch, on recirculation line (local read).
    iii. (1) Variable area rotameter, on blowdown line (local read).
    iv. (1) Flow totalizing indicator, on biofilter irrigation line (local read).
    v. (1) Solenoid valve, on biofilter irrigation line.
    vi. (1) Pressure indicator, on water supply line (local read).
    vii. (1) Lot fluid control valves and strainers.
13. Instrumentation and fluid control valves external to waterbox:
    i. (2) Air differential pressure indicators, across media beds (local read).
    ii. (1) Air temperature indicator, on inlet duct to system (local read).
    iii. (1) Temperature indicator, in biofilter media bed (local read).
    iv. (2) Pressure indicators, on inlet and outlet sides of the recirculation pump (local read).
    v. (1) Lot fluid control valves and strainers.
14. Winterization system:
    i. (1) 20 kW circulation heater for recirculation line, sheath material of construction to be Hastelloy, heater electrical enclosure to be NEMA 4X 304 stainless steel, circulation vessel material of construction to be 316 stainless steel.
    ii. (1) Space heater for control panel.
    iii. (1) Space heater for waterbox.
15. Engineering Submittal packages.
16. Operation and Maintenance manuals.
17. Field services will consist of the following:
    i. Two (2) consecutive days (1 trip) for system commissioning and operator training.
    ii. Two (2) consecutive days (1 trip) for performance testing. Includes taking four (4) odor samples to be analyzed by a third party laboratory.

Note: System equipment proposed is designed for a NFPA 820 Type C ventilation environment.

Contractor Scope of Supply

The following items listed are to be supplied by the Contractor and are not in the Manufacturer's Scope of Supply.

1. Provide all equipment offloading, temporary storage and placement.
2. Provide labor, materials and equipment for the installation and assembly of all Biorem supplied equipment and instrumentation. Supply and install all other materials or equipment required for a complete operational system.
3. Site preparation and clearing of materials.
4. Design and supply an appropriately sized reinforced concrete slab to handle full load of applicable vessels, fans, control panels and waterboxes. Provide collection and analysis of any geotechnical data as required.
5. Supply and install all required protective coatings or paint such as UV paint for piping or concrete paint.
6. Supply and install all external water piping and drain piping to and from vessels, waterboxes and other fluid equipment including heat tracing, insulation, piping supports, drainage traps where necessary and / or UV protective paint. If winterizing system, contractor to insulate differential pressure gauge enclosures.
7. Supply and install all hardware, supports, guide wires, duct gaskets, expansion joints and connectors needed for a complete and operational system.
8. Supply make-up water at a minimum pressure of 40 psi. Water analysis for hardness or other parameters as necessary.
9. Provide main electrical service and system field wiring outside the main odor control panel. All electrical requirements for heat tracing and equipment not specifically provided by Biorem to be provided by others.
10. Media onsite storage and installation. The Contractor shall be required to remove vessel access covers, install and distribute media evenly across the vessel, assemble media irrigation system and reinstall covers.
11. Provide duct balancing, and system functional, hydrostatic, vibration and performance testing to be conducted by OTHERS as may be specified.

Quotation

Item	Price
BiofiltAIR Concrete Biofilter System **(Please refer to Scope of Supply for details)**	**$ 169,500**

Delivery	Freight on board, jobsite
Commissioning	Included
Performance Testing	Included
Submittal Schedule	4 - 6 weeks after acknowledgement of order and confirmation from BIOREM's Project Manager
Delivery Schedule	12 - 14 weeks after approved submittals
Payment Terms	10% upon approvals, 80% upon delivery, 10% upon system commissioning
Price	All prices in US Dollars, applicable taxes are extra, prices are guaranteed for 90 days from date of quotation

Terms and Conditions

Pricing: Unless otherwise specified in writing by BIOREM, price does not include any taxes, excises, duties, tariffs or other governmental charges which BIOREM may be required to pay or collect under existing or future law with respect to the sale, transportation, delivery, storage, installation or use of any of the equipment sold by BIOREM.

Cancellation: Unless otherwise agreed in writing by the parties, the Buyer may not cancel the Order, except upon written notice and payment to Seller of an amount covering all costs incurred under the Order, all costs which arose out of the cancellation, and a cancellation fee of 50% of the Order Price. Materials received and Goods manufactured in part or whole under the Order prior to the time of cancellation shall be retained by and shall be property of the seller. When calculating the cancellation related costs, payments made by buyer to seller prior to cancellation shall be taken into account.

Limitation of liability: Seller's liability to the price allocable to the goods determined defective, and in no event will seller's cumulative liability be in excess of the total sales order price, whether arising under warranty, contract, negligence, strict liability, indemnification, or any other cause or combination of causes whatsoever. Seller will not be liable for any special, indirect, incidental, or consequential damages or indemnification, or any other cause or combination of causes whatsoever. This limitation shall apply notwithstanding any failure of essential purpose of any limited remedy. Buyer's remedies are specifically limited to the repair or replacement of the goods and is exclusive of all other remedies. Should these remedies be found inadequate or to have failed their essential purpose for any reason whatsoever, buyer agrees that return of the full sales order price to it by seller shall prevent remedies from failing their essential purpose and shall be considered by buyer as a fair and adequate remedy.

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biorem.biz

OUR PROMISE TO YOU

EXPERIENCE MATTERS

With more than 25 years of solving the most difficult air emissions challenges under adverse process conditions and intense scrutiny from customers, regulators and communities; each new project builds upon this immense knowledge base. As engineers, our goal is to continually innovate and improve so that your project benefits from the best available technology for superior results.

INTEGRITY RULES

BIOREM has established a rigorous code of ethics that upholds the highest level of ethical conduct, standards of practice and integrity pertaining to our professional duties. Anti-corruption measures are applied to all our projects from RFP through to commissioning and ongoing support.

Our partnerships with consulting engineers, contractors, municipalities, industry, suppliers and government regulators are carefully scrutinized and monitored to ensure our worldwide reputation for fair and transparent transactions is protected. We reserve the right to refuse business based on ethical considerations.

PERFORMANCE GUARANTEED

We guarantee that the performance of our products and systems will meet or exceed your expectations. From initial discussions where we learn about the problems that you need solving, through to expert assessments, precision manufacturing, timely distribution, user-friendly training and complete administrative support, we hold ourselves to the highest standards.

It is our promise to you

BIOREM Technologies Inc.
7496 Wellington Road 34,
Puslinch, ON Canada N0B 2J0

info@biorem.biz
1-800-353-2087
519-767-9100

BIOREM Environmental Inc.
100 Rawson Road, Suite 230
Victor, NY, 14564

info@biorem.biz
1-800-353-2087
519-767-9100

BIOREM (Beijing) Environmental Technologies Co., Ltd.
No. 2 Nan Zhu Gan Alley, Galaxy SOHO, Tower D, Suite 50322
Dongcheng District, Beijing, China

+86(10)6530 5080

Budgetary Proposal

Lower Scioto WRF Biofilters – Solids Handling

BIOREM Ref#: 18-4006

January 30, 2018

BIOREM

experience. integrity. performance.

Represented By:

Sullivan Environmental Technologies, Inc.

Wendell Smitley
1-614-395-7379
wendell@sullivanenvtec.com

Regional Sales Manager:
Dean Parker
585-455-0129
dparker@biorem.biz

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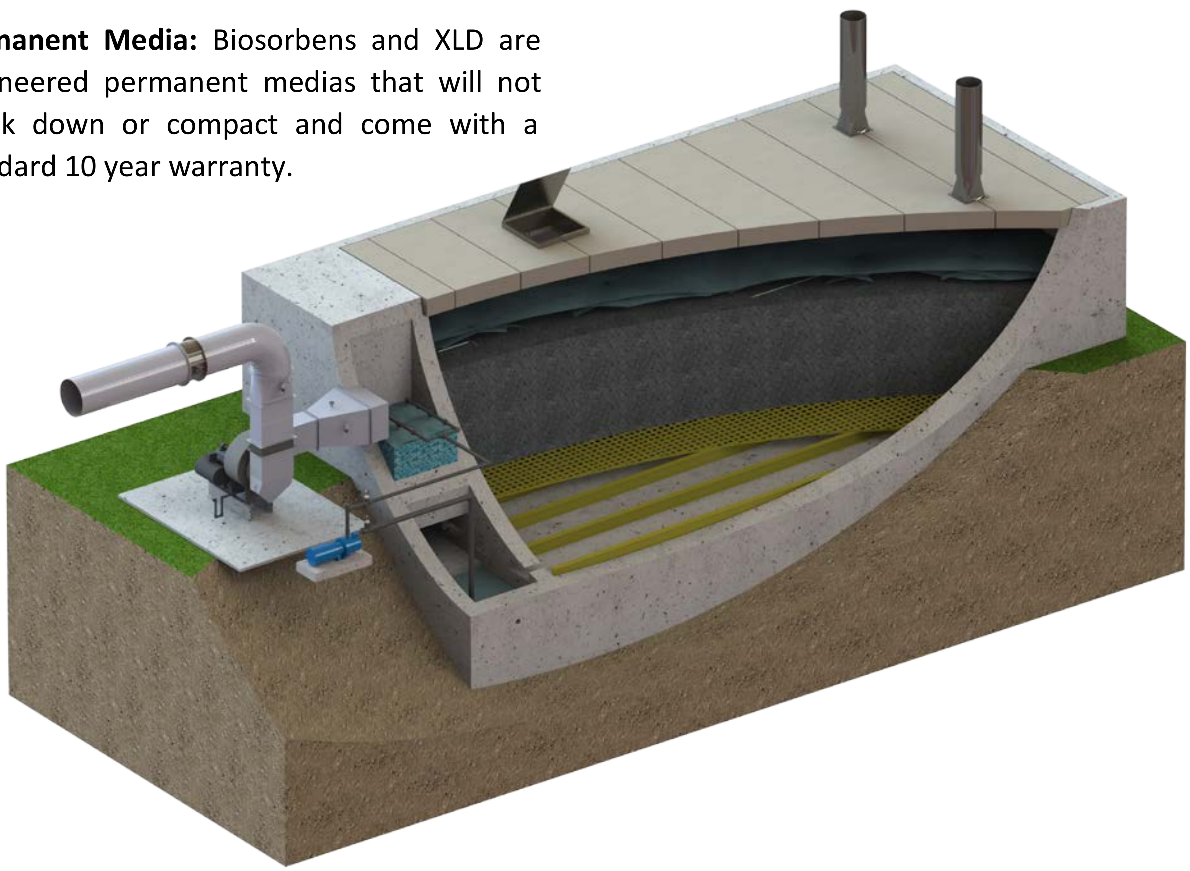

Revision History

Number	Description	Date	Author

Contents

Project Details

Table 1 - Inlet Foul Air Quality

Process Parameter	Value
Flow Rate	8,000 SCFM
Temperature	50 - 100 °F
Relative Humidity	>50% RH
Average H_2S Concentration	10 ppm (assumed)
Peak H_2S Concentration	20 ppm (assumed)
Organic Sulfur Compound Concentration	< 2 ppm (assumed)

Table 2: Overall System Configuration and Common Utilities

Design Parameter	Value
System Configuration	Site constructed biofilter
Water Supply Source	Potable preferred
Estimated Water Consumption	Approx. 300 GPD
Electrical Supply Required	460V / 3PH / 60Hz

Table 3: Biofilter Vessel Design

Design Parameter	Value
Number of Biofilter Vessels	1
Biofilter Vessel Dimensions	40 ft length : 25 ft width : 12 ft wall height
Number of Internal Treatment Stages	2: humidifier followed by biofilter
Humidifier Water Recirculation Rate	150 gpm
Humidifier Drain Water pH	5 - 8
Biofilter Drain Water pH	5 - 8

System Performance

A. When loaded under average conditions the biofiltration system will achieve at least 99 percent removal of H_2S for inlet concentration levels above 10 ppm. For inlet concentration levels less than 10 ppm, the outlet concentration levels shall be less than 0.1 ppm.

B. When loaded under average conditions the biofilter system shall provide at least 90 percent odor removal for inlet concentration levels between 6,000 and 15,000 OU. For inlet concentration levels less than 6,000, the outlet concentration levels shall be less than 600 OU. (Odor concentrations to be determined using ASTM-E679 with a 20 liter/minute odor panel presentation rate).

Warranties

A. The Manufacturer warrants that the biofilter media will not compact, degrade or decompose for a period of 10 years from the date of Substantial Completion, provided that the system is operated in accordance with the Manufacturer's printed Operation and Maintenance Manuals.

B. All mechanical components will be warranted free of manufacturing defects for a period of 12 months from Substantial Completion, or 18 months of shipment, whichever occurs first.

Scope of Supply

1. Concrete biofilter vessel structural design, supply and installation **by others**.
2. Biofilter media support flooring. Material of construction to be FRP grating and I-beams.
3. Humidification mass transfer packing, provided in boxes approximately 10 cubic feet in size.
4. Engineered biofilter media, provided in loose bulk .
5. (1) Butterfly damper for airflow isolation upstream of fan.
6. (1) Rectangular flexible transition piece on fan outlet, flange material of construction to be 304 stainless steel.
7. (1) 7.5 HP recirculation pump rated for 150 GPM at 100 ft head with a TEFC motor.
8. (1) Fan **provided by others**.
9. (1) Schedule 80 PVC manifold with spiral spray nozzles for optimized coverage of humidification media.
10. (1) Schedule 80 PVC manifold with matched precipitation rate nozzles for optimized coverage of biofilter media.
11. (1) Control Panel:
    i. NEMA 4X 304 stainless steel enclosure with pedestal legs.
    ii. Door mounted fused disconnect.
    iii. VFD and Hand/Off/Auto selector switch for exhaust fan.

  iv. Motor starter and Hand/Off/Auto selector switch for recirculation pump.
  v. Status lights for fan and recirculation pump.
  vi. Recirculation low flow alarm light.
  vii. Alarm reset push button.
  viii. Dry contacts for transmitting signals to a remote location.

12. (1) Waterbox:
    i. NEMA 4X 304 stainless steel pre-plumbed enclosure with pedestal legs.
    ii. (1) Flow indicator/switch, on recirculation line (local read).
    iii. (1) Variable area rotameter, on blowdown line (local read).
    iv. (1) Flow totalizing indicator, on biofilter irrigation line (local read).
    v. (1) Solenoid valve, on biofilter irrigation line.
    vi. (1) Pressure indicator, on water supply line (local read).
    vii. (1) Lot fluid control valves and strainers.
13. Instrumentation and fluid control valves external to waterbox:
    i. (2) Air differential pressure indicators, across media beds (local read).
    ii. (1) Air temperature indicator, on inlet duct to system (local read).
    iii. (1) Temperature indicator, in biofilter media bed (local read).
    iv. (2) Pressure indicators, on inlet and outlet sides of the recirculation pump (local read).
    v. (1) Lot fluid control valves and strainers.
14. Winterization system:
    i. (1) 30 kW circulation heater for recirculation line, sheath material of construction to be Hastelloy, heater electrical enclosure to be NEMA 4X 304 stainless steel, circulation vessel material of construction to be 316 stainless steel.
    ii. (1) Space heater for control panel.
    iii. (1) Space heater for waterbox.
15. Engineering Submittal packages.
16. Operation and Maintenance manuals.
17. Field services will consist of the following:
    i. Two (2) consecutive days (1 trip) for system commissioning and operator training.
    ii. Two (2) consecutive days (1 trip) for performance testing. Includes taking four (4) odor samples to be analyzed by a third party laboratory.

Note: System equipment proposed is designed for a NFPA 820 Type C ventilation environment.

Contractor Scope of Supply

The following items listed are to be supplied by the Contractor and are not in the Manufacturer's Scope of Supply.

1. Provide all equipment offloading, temporary storage and placement.
2. Provide labor, materials and equipment for the installation and assembly of all Biorem supplied equipment and instrumentation. Supply and install all other materials or equipment required for a complete operational system.
3. Site preparation and clearing of materials.
4. Design and supply an appropriately sized reinforced concrete slab to handle full load of applicable vessels, fans, control panels and waterboxes. Provide collection and analysis of any geotechnical data as required.
5. Supply and install all required protective coatings or paint such as UV paint for piping or concrete paint.
6. Supply and install all external water piping and drain piping to and from vessels, waterboxes and other fluid equipment including heat tracing, insulation, piping supports, drainage traps where necessary and / or UV protective paint. If winterizing system, contractor to insulate differential pressure gauge enclosures.
7. Supply and install all hardware, supports, guide wires, duct gaskets, expansion joints and connectors needed for a complete and operational system.
8. Supply make-up water at a minimum pressure of 40 psi. Water analysis for hardness or other parameters as necessary.
9. Provide main electrical service and system field wiring outside the main odor control panel. All electrical requirements for heat tracing and equipment not specifically provided by Biorem to be provided by others.
10. Media onsite storage and installation. The Contractor shall be required to remove vessel access covers, install and distribute media evenly across the vessel, assemble media irrigation system and reinstall covers.
11. Provide duct balancing, and system functional, hydrostatic, vibration and performance testing to be conducted by OTHERS as may be specified.

Quotation

Item	Price
BiofiltAIR Concrete Biofilter System (Please refer to Scope of Supply for details)	**$ 235,000**

Delivery	Freight on board, jobsite
Commissioning	Included
Performance Testing	Included
Submittal Schedule	4 - 6 weeks after acknowledgement of order and confirmation from BIOREM's Project Manager
Delivery Schedule	12 - 14 weeks after approved submittals
Payment Terms	10% upon approvals, 80% upon delivery, 10% upon system commissioning
Price	All prices in US Dollars, applicable taxes are extra, prices are guaranteed for 90 days from date of quotation

BIOREM

Terms and Conditions

Pricing: Unless otherwise specified in writing by BIOREM, price does not include any taxes, excises, duties, tariffs or other governmental charges which BIOREM may be required to pay or collect under existing or future law with respect to the sale, transportation, delivery, storage, installation or use of any of the equipment sold by BIOREM.

Cancellation: Unless otherwise agreed in writing by the parties, the Buyer may not cancel the Order, except upon written notice and payment to Seller of an amount covering all costs incurred under the Order, all costs which arose out of the cancellation, and a cancellation fee of 50% of the Order Price. Materials received and Goods manufactured in part or whole under the Order prior to the time of cancellation shall be retained by and shall be property of the seller. When calculating the cancellation related costs, payments made by buyer to seller prior to cancellation shall be taken into account.

Limitation of liability: Seller's liability to the price allocable to the goods determined defective, and in no event will seller's cumulative liability be in excess of the total sales order price, whether arising under warranty, contract, negligence, strict liability, indemnification, or any other cause or combination of causes whatsoever. Seller will not be liable for any special, indirect, incidental, or consequential damages or indemnification, or any other cause or combination of causes whatsoever. This limitation shall apply notwithstanding any failure of essential purpose of any limited remedy. Buyer's remedies are specifically limited to the repair or replacement of the goods and is exclusive of all other remedies. Should these remedies be found inadequate or to have failed their essential purpose for any reason whatsoever, buyer agrees that return of the full sales order price to it by seller shall prevent remedies from failing their essential purpose and shall be considered by buyer as a fair and adequate remedy.

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Our partnerships with consulting engineers, contractors, municipalities, industry, suppliers and government regulators are carefully scrutinized and monitored to ensure our worldwide reputation for fair and transparent transactions is protected. We reserve the right to refuse business based on ethical considerations.

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We guarantee that the performance of our products and systems will meet or exceed your expectations. From initial discussions where we learn about the problems that you need solving, through to expert assessments, precision manufacturing, timely distribution, user-friendly training and complete administrative support, we hold ourselves to the highest standards.

It is our promise to you

BIOREM Technologies Inc.
7496 Wellington Road 34,
Puslinch, ON Canada N0B 2J0

info@biorem.biz
1-800-353-2087
519-767-9100

BIOREM Environmental Inc.
100 Rawson Road, Suite 230
Victor, NY, 14564

info@biorem.biz
1-800-353-2087
519-767-9100

BIOREM (Beijing) Environmental Technologies Co., Ltd.
No. 2 Nan Zhu Gan Alley, Galaxy SOHO, Tower D, Suite 50322
Dongcheng District, Beijing, China

+86(10)6530 5080