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Project name:
MSD Odor Control Master Plan

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Final Memo

Subject: Technical Memorandum #8C – Morris Forman Selected Pump Stations New Odor Control Technologies Recommendation

1. Introduction

1.1 Odor Control Master Plan Background

In response to receiving a Notice of Violation (NOV) in November 2019 for failure to control nuisance odors from the Morris Forman Water Quality Center (WQTC, Plant), pumping stations and its collection system, MSD entered into an agreed order with the Louisville Metro Air Pollution Control District (APCD) to develop and implement a phased District-wide Odor Control Master Plan. MSD has contracted AECOM to provide MSD with professional engineering services for the development of Phase I of the Odor Control Master Plan (Odor Control Master Plan), which is focused on the Morris Forman Service Area. MSD also contracted with a public relations firm to increase public engagement and communications during development and implementation of the phased Odor Control Master Plan.

MSD owns and operates 137 wastewater pump stations within the Morris Forman Service Area. These pump stations are responsible for the conveyance of wastewater flow from the Morris Forman combined sewer collection system towards the Morris Forman WQTC. Several communities in the Morris Forman Service Area have experienced nuisance odors leading to a significant amount of complaints, specifically during the summer of 2019. Primary affected residents were in the Chickasaw, California, and Park DuValle neighborhoods. These complaints led to the development of a dedicated Odor Control Master Plan for the Morris Forman Service Area.

1.2 Purpose

This technical memorandum is intended to identify new odor technologies that may be potential options to implement into the Morris Forman selected pump stations.

1.3 Previous Documentation and Implementation Schedule

In accordance with the agreed order, MSD has submitted several documents to APCD to demonstrate ongoing odor control efforts. Table 1 shows MSD's completed and ongoing efforts towards the APCD agreed order.

Table 1 – Phase I Master Plan Implementation Schedule

Title		Due Date	Status
TM#1	Morris Forman WQTC Background Document Review	Q1 2021	Completed
TM#2	Collection System Background Document Review	Q2 2021	Completed
TM#3	Pump Stations Background Document Review	Q2 2021	Completed
TM#4	WQTC, Pump Stations and Combined Sewer System Planned Process Modifications	Q1 2021	Completed
TM#5	Current WQTC, Pumping Stations and Combined Sewer System Odor Impact Evaluation	Q2 2021	Completed
TM#6A, TM#6B, TM #6C	Morris Forman WQTC (TM#6A), Collection System (TM #6B), and Pump Stations (TM #6C) Sampling Phase Results Analysis	Q4 2022	Completed
TM#7A, TM#7B, TM#7C	Morris Forman WQTC (TM#7A), Collection System (TM #7B), and Pump Stations (TM #7C) Current Odor Technologies Performance Evaluation	Q4 2022	Completed
TM#8A, TM#8B, TM#8C	**Morris Forman WQTC (TM#8A), Collection System (TM #8B), and Pump Stations (TM #8C) New Odor Control Technologies Recommendation**	**Q4 2022**	**Ongoing**
TM#9	**Odor Control Conceptual Design**	**Q4 2022**	**Ongoing**
Odor Control Master Plan Phase I Final Report		**Q4 2022**	**Ongoing***

**- The Final Odor Control Master Plan Phase I Final Report will be a comprehensive document which includes information about the Morris Forman Collection System, WQTC, and selected pump stations.*

2. Summary of Sampling Results

Liquid and Vapor sampling was performed in 2021 and 2022 at multiple locations within the selected pump stations in the Morris Forman service area. The sampling program and full summary of results can be found in TM #6C under separate cover. The results were analyzed, and locations were assigned an odor control priority based on vapor sampling results, as shown in Table 2.

Table 2 – Collection System Vapor Sampling Results Summary

Sampling Location	Potential Odor Receptors	Target Limit Exceedance(s)	Odor Control Priority
S2: PS #5 Splitter Structure #1	Park DuValle residents; Adjacent properties	Odor, H_2S, Methyl Mercaptan	High
ND1: PS #4 Lower Level	Wyandotte/Beechmont residents; Adjacent properties	Odor	High
S1: PS #5 Dumpster Room	Park DuValle residents; Adjacent properties	Odor, Methyl Mercaptan	High
ST1: PS #6 Lower Level	Downtown residents; Adjacent Properties	Odor	High
F1: PS #8 Lower Level		Odor	High
ST2: PS #6 Roof Exhaust		Odor	High
F2: PS #8 Roof Exhaust		Odor	High
G1: PS #2 Carbon Inlet	Jeffersontown; Adjacent properties	Odor	Moderate
N4: PS #3 System 2 Outlet	Germantown & Deer Park residents	Odor	Moderate
N3: PS #3 System 2 Inlet		Odor	Moderate
S1: PS #5 Dumpster Room	Park DuValle residents; Adjacent properties	Odor, Methyl Mercaptan	Moderate
G2: PS #2 Carbon Outlet	Jeffersontown residents; Adjacent properties	Odor	Moderate
N1: PS #3 System 1 Inlet	Germantown & Deer Park residents	Odor	Moderate
N2: PS #3 System 1 Outlet		Odor	Low
U2: PS #7 Bar Screen Channel Exhaust	Deer Park residents; Adjacent properties	Odor	Low
U1: PS #7 Wet Well Room		Odor	Low
S3: PS #5 Influent Junction Structure	Park DuValle residents; Adjacent properties	-	N/A

Based on these results, odor control will be considered in the following locations / areas:

- Pump Station #4
- Pump Station #6
- Pump Station #8
- Pump Station #3
- Pump Station #2

3. Odor Control Technology Review

Feasible odor control technologies were identified and evaluated for odor removal efficiency, applicability, advantages and disadvantages. Table 3 identifies the various odor control measures which will considered for inclusion into the Pump Station Odor Control Master Plan. Liquid treatment technologies are not included in this discussion because no liquid treatment solutions are recommended to control the odor emissions at the pump station facilities.

Table 3 - Odor Treatment Technology Summary

	Odor Control Technology	Description	Configuration(s)
Vapor Treatment Technologies			
1	Adsorption	Attachment of odorous vapor compounds to surfaces	Dry media scrubbers, fixed bed reactors or adsorber wheel; Can be combined with bioscrubber or biofiltration
2	Biological	Degradation of odorous vapor compounds via microorganisms	Biofilters, Bioscrubbers and biotrickling filters
3	Photoionization (UV)	Use of ultraviolet (UV) light and catalyst to oxidize odorous compounds	Ionization chambers
4	Hydroxyl Generator	Use of UV and optics to oxidize odorous compounds via hydroxyl molecules	Positive pressure systems involving process fans
5	Hydroxyl Advanced Oxidation	Use of ozone, water and air to oxidize odorous compounds via hydroxyl molecules	Positive pressure systems involving process fans

3.1 Adsorption

Adsorption involves the attachment of odorous compounds to a solid surface and is typically performed in conjunction with biological treatment. Common adsorbents include activated carbon, activated alumina, and silica gels. Carbon has a high surface-to-volume ratio, providing a large amount of surface area for odors to be adsorbed. The media adsorbs a wide variety of odorous compounds including H_2S and odor causing organic compounds. In an activated carbon odor treatment system, pollutants are removed from the air by physical adsorption onto the surface of the activated carbon particles. Media specific to odor control applications can be supplied impregnated with alumina, or other chemical binders, which also absorb and oxidize adsorbed odor contaminants. The odorous gases are collected and held within the media pores where through oxidation the contaminants are converted to a harmless solid substance which remains in the media. Other dry media types can be combined with activated carbon media within an odor control system to enhance the odor removal performance of the unit. Media impregnated with potassium or sodium permanganate increase the range of odor causing compounds which can be removed from an odorous inlet airflow. Organic compounds, along with reduced sulfur compounds, aldehydes, and H_2S, can be removed by these types of dry media. An example photo of a carbon adsorption system is shown in Figure 1.

Operation of dry media odor control units is straightforward. The media bed can be arranged for either vertical or horizontal airflow through the treatment vessel. Vertical airflow systems are usually contained within cylindrical vessels where odorous air enters the bottom of the unit and flows upwards through the media to be discharged from the top of the unit. Horizontal airflow units arrange the media in a “V” shape from the bottom to top of the unit vessel. Air passes through the “V” media beds from the open end of the “V” to the point at the exhaust side. Horizontal airflow vessels are not as tall as cylindrical units and are supplied with access hatches on the top of the unit for easy media replacement. Due to the short retention time required in a dry media system, the footprint of a vessel is less than that of a biofilter while being able to control the same wide range of odor causing compounds.

Figure 1 – Example Carbon Adsorption System

Dry media selected for odor control applications must be capable of performing within an airstream that has a high relative humidity when removing odors from a wastewater source. Humidity in wastewater applications can reach over 98%. Condensation can wet the dry media and fill void spaces that are the sites of odor removal. Media with hydrophobic properties can resist high humidity environments but further protection from condensation and water droplets may be required. A mist eliminator should be installed on the inlet side of the vessel to trap any fines, greases, or water droplets entrained within the airstream. Inlet dehumidification may be required in very wet inlet airflows where ambient and process temperature differences will lead to significant condensation formation. Dehumidifiers warm the air to reduce the relative humidity of the air and help to warm the media and process vessel. While effective, dehumidification is an energy intensive process that is high in operating and maintenance costs. Keeping the inlet odorous air, dry media, and vessel close in temperature range minimizes condensation formation without the need for dehumidification. This can be achieved by insulating the dry media unit to minimize the temperature difference between the media, vessel walls, and process air.

Dry media units are sized based on the mass inlet loading of odorous compounds and the inlet air velocity. To ensure a reasonable media life, the volume of dry media within a vessel can be sized to hold a specific mass of odor compounds. Dry media removes 99.5% of all inlet odor compounds until the media capacity to do so has been reached. The media in a unit is spent when all the void space within the media is full with adsorbed and oxidized odor contaminants. When this occurs any additional odor compounds will pass through the vessel until the existing media is replaced with a new batch. The life of the media will be longer with lower inlet odor concentrations. When odor loading is high, the void space in the media is more rapidly filled which reduces the system life and increases the frequency of media replacement.

3.2 Biological Treatment

Biological systems rely on the activity of microorganisms to degrade organic contaminants from the vapor stream. The microorganisms feed on odorous substances and oxidize them. The oxidation is a conversion from the odorous compounds to CO_2, H_2O or other odorless compound(s). Therefore, biological systems sustainably reduce odorous emissions and do not leave residues (such as scrubbing liquids or adsorbents). In addition, biological treatments inherently do not require the addition of chemical agents and do not have large associated energy costs as they are operated at atmospheric pressure and ambient temperatures. The materials, installation, and operational costs for biological systems are often the lowest among odor control technologies.

3.2.1 Biofilters

Biofiltration is an odor control technology involving physical adsorption, aqueous absorption, and bacterial oxidation of odorous compounds. Fundamentally, a biofilter is a box filled with a media such as soil, compost, or an engineered inorganic substrate, to support the growth of bacteria which metabolize odorous compounds present in a foul air stream. Biofilters have been used to treat odors in a number of different applications ranging from various wastewater treatment plant processes, pumping stations, collection systems, and food waste recycling plants among others.

Biofilters are versatile in their design and can be constructed as in-ground basins, stand-alone containers, or above-ground units. Units can be provided as packaged systems with their own Stainless Steel or Fiber Reinforced Plastic vessels (see Figure 2 and Figure 3 for example), or they can be constructed on-site with the pouring of a concrete vessel. Biofilters can be either covered by a roof or removable panels or left uncovered for air to disperse directly out from the media. Also, for flow rates up to 10,000 cfm are available as a modular unit including the fan and the exhaust stack. Covered designs allow treated air to be routed to an external stack for discharge producing an elevated dispersion profile of exhausted air. The design of large units is more expensive in capital cost, but it provides better performance in terms of off-site odor impingement to the sensitive receptors.

A disadvantage of biofilters is that sulfurous and nitrogenous organic or inorganic compounds that transit through the filter bed media can cause acidification due to their oxidization products (e.g., sulfuric, and nitric acid). In these situations, a combination with other treatment processes should be considered.

Due to the relatively long retention time through the media bed, the technology is best suited for moderate airflow volumes. Large airflow rates will require a larger footprint may only be practical if the space for a unit is available.

Figure 2 – Example Biofilter Configuration

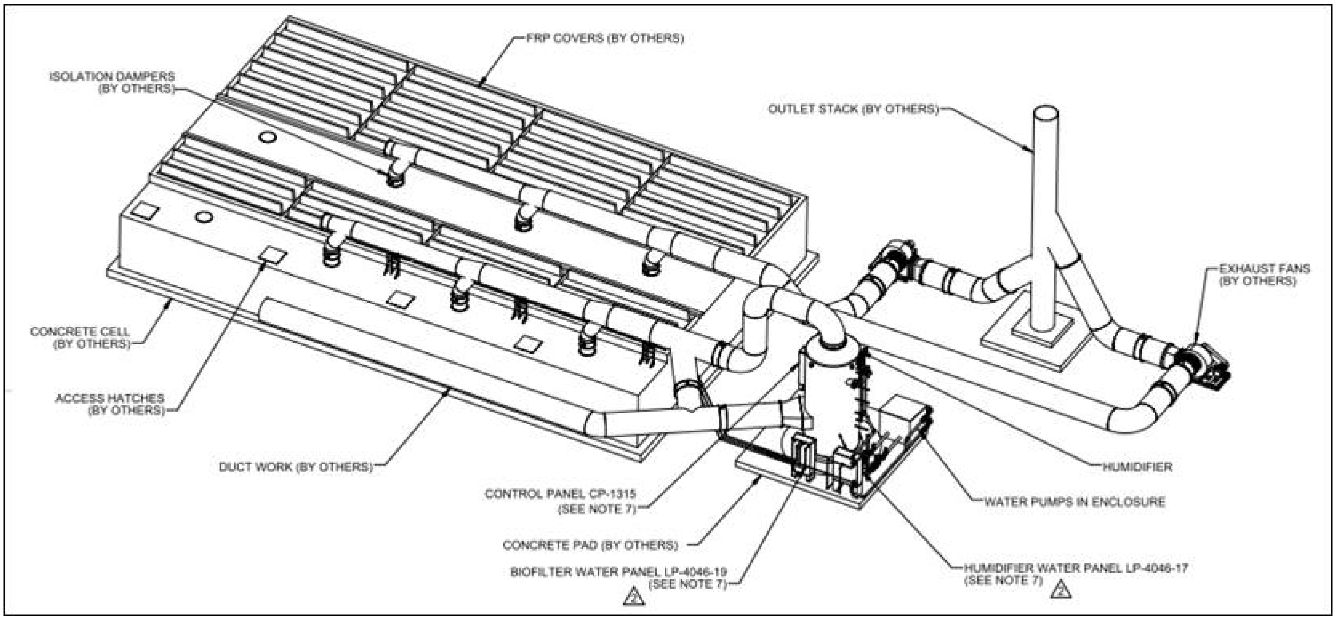

Figure 3 – Example Biofilter Schematic

Different types of media can be utilized in a biofilter system. Practical experience has shown that yard compost, sludge compost, and wood and bark chips are used in removing H_2S and other odor causing contaminants. Engineered inorganic media has been developed using inert substrates on which various buffers and nutrients have been impregnated to support an optimal environment for microbial oxidation of odorous compounds. The engineered media is resilient to compaction and settling which lead to increase pressure drop across the media and reduced removal efficiencies. Compared to organic media, engineered inorganic media generally has higher and more consistent removal efficiency along with a longer media life. Media replacement is between 2 to 4 years for organic media and 10+ years for engineered inorganic media.

Biofilters are very effective at treating a wide range of odor causing compounds including H_2S, organic reduced sulfur compounds (such as methyl mercaptan (MM), dimethyl sulfide (DMS), and ethyl mercaptan (EtSH)), and selected volatile organic compounds (VOCs) when the contaminants loadings are within the limits of the biofilter media performance removal. When the average H_2S inlet loading is above 30 ppm, the pH of the bed is prone to be lowered due to the higher incidence of sulfuric acid as a by-product of microbial H_2S metabolization. This can reduce the removal of organic reduced sulfur compounds and VOCs, as these compounds are more readily oxidized at a neutral bed pH. At high H_2S loadings (>30 ppm), the biofilter also starts to oxidize H_2S to element sulfur which deposits inside the media which can result in a higher pressure drop across the media. Greater pressure drop requires more power to be consumed by the biofilter process fan to move the odorous air through the media bed for treatment. If H_2S levels are lower, i.e., and average of nearly 0 ppm for an extended period of time (3 to 4 months), there will be a drop in microbe population as the H_2S “food” is in lower supply. The system will continue to remove H_2S, however. If for some reason the biofilter is turned off for an extended period of time, the population of microbes metabolizing the odor contaminants will die off. This does not impact the life expectancy of the media. The system can be returned to operation and over a few weeks the microbe population will grow back to consume and treat the inlet H_2S. Removal efficiency will increase as the microbe population is reinstated during the acclimation period. This also occurs during system start-up and commissioning. Vendors recommend performance testing of a new system to be completed following a three (3) to four (4) week acclimation period.

Biofilters require less maintenance than other odor treatment technologies as there are limited moving parts aside from the process fan(s) and pump(s) for recycling pre-treatment humidification water. Inorganic media is designed to last 10 years or more and therefore will only rarely require media removal and replacement. Water is needed to humidify the inlet air to 99% relative humidity to aid in the biofiltration process or for irrigation of the media as specified by the vendor. The humidification chamber can be integrated into a packaged, or on-site constructed concrete biofilter vessel. Inlet air travels through a packing material which is continuously sprayed with water. The packing and spraying create water droplets through turbulence which increases the water surface area and aids in humidifying the inlet air stream. The humidity in the air aids in the adsorption of odorous contaminants onto the moist biofilm which surrounds the media treatment particles and supports the odor metabolizing microbes. Water also needs to be applied to the media bed at vendor defined intervals to keep the biofilter media bed moist and clean it of any biomass or elemental sulfur buildup. This process is called irrigation and typically occurs for an hour or two every few days. The water used in the humidification chamber can be collected in a sump and recirculated back through the spray headers and packing, while the water for irrigation cannot be recycled. Due to the by-products that the irrigation water washes from the media bed it is not advised to reuse the water for irrigation. If a bioscrubber unit is paired upstream with a biofilter system a humidification system is no longer required.

Typical removal efficiency of H_2S through a biofilter is 99%. This is accompanied with removal of other odor causing compounds such as those present in the STS air; MM, DMS, and EtSH. Odor is removed by greater than 90% as well.

3.2.2 Bioscrubbers

Bioscrubbers are similar to biofilters as they are both based on aqueous adsorption, absorption, and bacterial oxidation of the odorous contaminants. Similar to a biofilter, odorous air is moved through a bed of high surface area media in which microorganisms grow and biodegrade the odorous contaminants of the inlet air. The media used in bioscrubbers is inorganic and engineered by specialist vendors to withstand the low pH (1-3) environment which develops through oxidation of H_2S in the system. The media is designed to last for 10 years or more and is typically guaranteed for 10 years of service before requiring a media bed change out. In contrast to biofilters, where irrigation is periodic, water is continuously sprayed and distributed over the top of the media counter-currently to the flow of air. This humidifies the air in the same was as a dedicated humidification chamber. Airflow travels from underneath the media, up through the bed, and then out of the unit to further treatment stages or directly exhausted to the atmosphere. Due to the bottom-up airflow configuration bioscrubbers are commonly designed in a tower configuration. Horizontal airflow through a bioscrubber system is not common. However, to lower the elevation of a bioscrubber treatment tower some vendors offer units which come with a number of individual bioscrubber cells which each treat a fraction of the overall system airflow to reduce the height of the unit. The downside to this is increased process piping and media to maintain. Like a biofilter system a concrete vessel can be used to house a bioscrubber. However, due to the low pH of recycled process water in the system the vessel needs to be lined for corrosion protection. The benefits of a concrete vessel include a reduced system height as the system footprint can be poured on-site and enlarged over a pre-constructed fiber-reinforced plastic tower unit.

The water spray headers are located at the top of the vessel and deliver water down onto the top of the media counter-current to the airflow direction. Water percolates through the media and is collected at the bottom of the vessel in a sump. Water is returned to the spray headers at the top of the unit through recirculation pumps located adjacent to the units. The microbes which oxidize H_2S prefer an acidic environment and create sulfuric acid as a by-product of H_2S treatment. The pH of the recirculated water in the system is at an optimal condition when ranging from 1 to 3. To maintain the quality of the recirculated water, a small percentage is blown down to the drain. The water is made-up by the addition of new clean water to the bioscrubber sump. An example picture and schematic of a bioscrubber is shown in Figure 4.

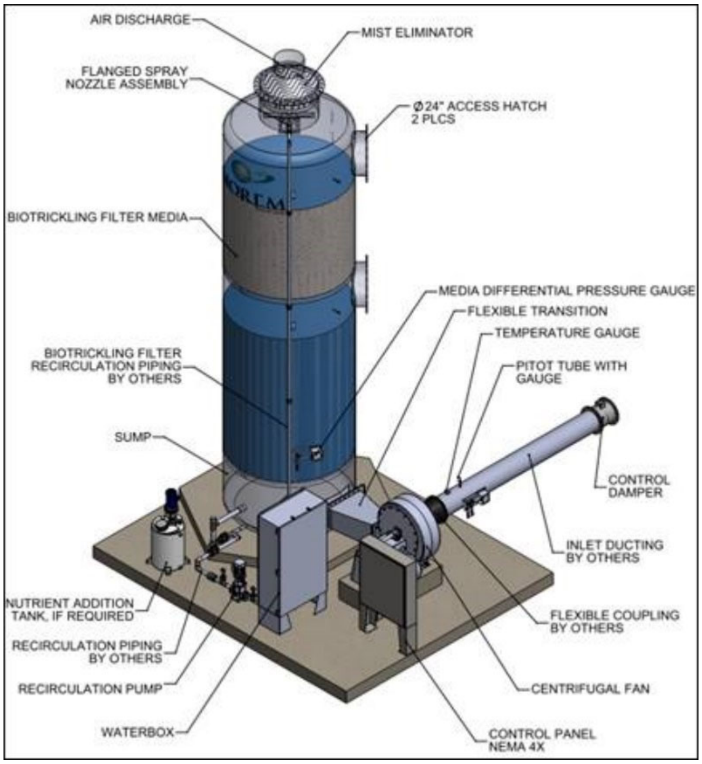

Figure 4 - Example Bioscrubber Filter System

Bioscrubbers have a lower media bed retention time than biofilters. The reduced retention time results in a lower volume of media required to treat the inlet odorous air. The footprint of bioscrubbers is therefore smaller than that of biofilter systems. Bioscrubbers are excellent at removing high levels of H_2S, over a range of 50 to 400 ppm, but have limited capacity in removing other compounds such as MM, DMS, EtSH and VOCs. For this reason, bioscrubbers are most effective for applications where inlet H_2S levels are high. However, they do still remove low level H_2S concentrations effectively. AECOM has installed bioscrubber systems in applications where the average H_2S concentration is 2 ppm. The systems run effectively at the low H_2S level, while providing capacity for higher levels of H_2S is present in the future. Like biofilters, the microbe population which metabolizes the odor compounds grows to equilibrium with the available “food” (H_2S). Odor removal for a bioscrubber only system is low at a minimum of 75%. This is due to the low removal rates of the reduced sulfur compounds aside from H_2S.

The presence of other odor causing compounds requires a second stage treatment technology to maximize removal efficiencies. When paired with a second stage such as dry media or photoionization technology, the system can be highly effective at cleaning air with multiple odor compounds and a high H_2S loading. The upstream bioscrubber would act as pre-treatment stage to remove inlet H_2S, and he dry media unit would capture the remaining low concentration odor contaminants and any remaining H_2S. As the media bed life of a dry media system is determined by the concentration of inlet odor contaminants, by including a bioscrubber to remove H_2S upstream of a dry media unit, the bed life expectancy of the dry media would be extended over that if was the only employed odor control technology.

Bioscrubber maintenance is similar to that of an inorganic media based biofilter, aside from requiring a nutrient solution to be added to the recirculated water in the system to support the health of the microbes. Water is continuously sprayed over the media bed to assist in phase transfer of the contaminants to the microbes, and as a continuous source of nutrients and favorable microbial environmental conditions. The nutrient solution can be continually added to the recirculated water by the use of small metering pumps. The nutrient solution can be pumped out of a dedicated storage tank, but the solution will need to be mixed and prepared by maintenance staff at least once a month. If exposed to the elements the water in the bioscrubber sump can freeze during winter months. The water will need to be heated to avoid freezing and maintain the temperature of the inlet air at, or above, 50°F. Below 50°F the microbes begin to slow the rate at which they oxidize H_2S. This will reduce the removal efficiency performance of the system. To warm the water and air, an immersion heater can be installed within the sump and programmed to turn on below a certain water temperature, say 53°F for example. To ensure the heater element is not exposed to the inlet air, the level of the sump water must be monitored by an ultrasonic device, or float switch. If the water level drops too low, the heater will be commanded to shut-off and not be allowed to turn-on until the water level is restored. By enclosing the bioscrubber system and sump within a dedicated heated building the need for heating the sump water will be reduced as the unit would be better protected from the elements and ambient temperature. By doing this the heating requirements of a bioscrubber can be reduced.

Since the pH of the recirculated water is low (1-3), the water blown down to the drain to maintain water quality in the scrubber unit may need to be neutralized before being drained away from the unit. Most clients dictate the minimum, or maximum, pH of a solution that can be drained into sewer systems. A caustic addition system which doses the water drained from the bioscrubber with a basic solution to neutralize the pH of the water can be used to meet requirements. The use of caustic can create handling and safety issues for maintenance operators if a system is required. The addition of a caustic system should be avoided, if possible, to minimize maintenance and chemical handling by operations staff.

3.2.3 Biotrickling Filters

These systems work similarly in that they use microorganisms, media and water. Odorous or polluted air is collected and forced up through the structured media within the vessel. But in biotrickling filters, the microorganisms grow within the media.

The key differentiator of biotrickling filters is that they do not recirculate water. The water used in these systems passes through only once and acts mainly as a rinse to drain the metabolized compounds away. And while at first glance this might seem inefficient, biotrickling filters and bioscrubbers actually use identical amounts of water to treat identical airflows. An example schematic biotrickling filter is shown in Figure 5.

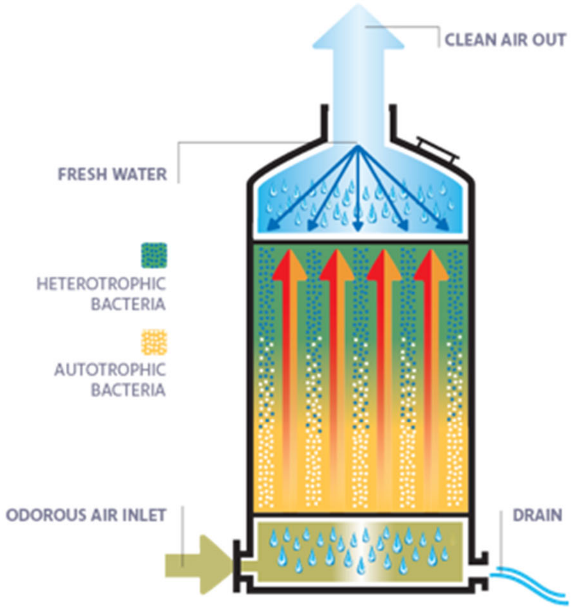

Figure 5 – Example Biotrickling Schematic

Research has shown that biotrickling filters support a greater diversity of bacteria. As impacted air is forced upward through the vessel, it encounters different types of microorganisms. That diversity has been shown to eliminate more, and more kinds, of the compounds produced in industrial processes. This is why biotrickling filters can remove a host of compounds —such as H_2S, NH3, volatile fatty acids, organic odors and select VOCs— with great efficiency.

Bio Trickling filter, known as BTF is based on much simple operational principle. In the BTF, micro-organisms responsible for the biodegradation of the target pollutants are immobilized on special inert material or packing which provides surface area and favorable environment for the growth of micro-organisms on it.

3.3 Photoionization (UV)

Photoionization utilizes ultraviolet (UV) light and a catalyst to oxidize odor compounds such as H_2S. The system is composed of ionization chambers where UV bulbs produce hydroxyl and oxygen radicals. The radicals react with and oxidize the odor compounds within the inlet airflow in the presence of the UV chamber and catalyst. The catalyst is typically a carbon based medium and captures compounds not broken down within the UV chamber. This technology is very effective at oxidizing and removing wastewater odors. Its performance is also not negatively impacted due to high inlet air humidity and can be turned off for extended periods of time without reducing the systems performance once returned to operation again. No water or additives are needed for system operation. Only electricity to power the UV bulbs is needed.

UV systems have the ability to achieve 99.5% removal of influent H_2S. As concentration increases the removal efficiency also increases. This is due to the treatment limits of RSCs compared to the moderate average concentration loadings. Odor concentrations are reduced by at least 99%. However, while used in Europe for more than a decade, photoionization to treat odors in North America is relatively new when compared to other treatment methods. Reliability and effectiveness of the treatment method is not as well established as bio-treatment or carbon media.

If the reaction within the ionization chamber is not fully complete, oxygen radicals can pass through the system and be discharged into the environment. The catalyst is to capture any remaining radicals as they are highly oxidative and hazardous if they come into contact with oxidants or people. Ozone monitors will be equipped on the exhaust to ensure that the treatment system is shutdown if ozone is detected in the treated air, but regular maintenance of the UV bulbs and catalyst are the best practice to avoid any breakthrough. Yearly replacement of the catalyst and UV bulbs is required to maintain a properly functioning system.

Access to the bulbs and catalyst is through a maintenance door on each treatment chamber. The system is to be run under negative pressure with the process fans on the clean-air side of the photoionization unit pulling air through the treatment equipment. This arrangement is needed as air can leak through the chamber doors. If air is being pushed through the unit, rather than pulled, untreated air or ions can escape through leaks in the doors. By running under negative pressure any air leaks will bring ambient air into the system instead.

Photoionization systems are composed of individual treatment chambers as shown in Figure 6. To create a system sized to treat the required airflow, the chambers are added together into units. Photoionization systems are supplied in modular chambers which have a set airflow capacity. Chambers are added until the cumulative airflow capacity of all the photoionization chambers equal that of the inlet airflow volume. Depending on the system vendor, between 14 to 20 UV bulbs will be installed in each chamber. These UV bulbs are responsible for the high energy demand of photoionization systems (38 kW), which is the highest of all the single-stage technologies evaluated.

Figure 6 – Photoionization Example Photo

Source: Neutralox Umwelttechnik GmbH represented by Ambio

3.4 Hydroxyl Generator

Hydroxyl generators create the hydroxyl radicals (OH) using ozone, water and air, which are blown via a process fan to inject the hydroxyl into a headspace to remove contaminants. The units use positive pressure to move the radicals into the area where odors are to be treated which differs from photoionization where the treatment occurs within the UV chamber and catalyst. Some manufacturers utilize UV bulbs and optics to create the radicals that provide reduction of odors through containment and oxidation. Figure 7 shows a unit with UV.

The surface pH in wet well areas can reach low levels depending on the chemistry of the wastewater, which causes corrosion within the wet well area. A hydroxyl generator unit covers the entire area to remove odors and bacteria, which helps to raise the pH closer to neutral and thereby reduce corrosion on the infrastructure. In addition, the chemical process can break down the double carbon bonds that form fatty acid chains which also reduces odor and fats, oils, and grease (FOG) within the system.

Hydroxyl generators can be installed indoors or outdoors, and some units can be integrated into an existing HVAC system for use. The units are relatively small and treat a relatively large area, therefore are ideal for small pump station facilities. The hydroxyl generator is recommended not to be installed inside the area treated for the odorous compounds. The unit is using ambient air and since it is resulting in an additional volume of air, a vent or goose neck is recommended to be added to discharge the treated air outdoors.

Figure 7 – Hydroxyl Generator Example Photo – Unit with UV (Pyure Dynamic Protection)

3.5 Hydroxyl Advanced Oxidation

The system is using air automized fluid nozzles to create Hydroxyl radicals, one of the most potent vaporized oxidants.

The nozzle combines ozone, water and air to create a hydroxyl radical mist that efficiently disperses throughout enclosed spaces such as: lift station, wet well, holding tanks, diversion boxes.

This technology attacks biofilm on surfaces that lead to costly infrastructure corrosion. The surface pH in wet well can be as low as 1 but the powerful oxidant mist covers the entire surface eliminating the bacteria that metabolizes H2S in sulfuric acid. The mist raises the pH above 6 and preserves the infrastructure. Hydroxyl radicals efficiently oxidize reduced sulfur compounds, amines and volatile fatty acids.

The system will require H_2S monitoring unit to activate the mist deployment in the process area. Odor treatment generators can be installed indoors or outdoors and can be integrated into an existing HVAC system for use. The units are relatively small and treat a relatively large area, therefore are ideal for small pump station facilities. The hydroxyl generator is recommended not to be installed inside the area treated for the odorous compounds. The unit is using ambient air and since it is resulting in an additional volume of air, a vent or goose neck is recommended to be added to discharge the treated air outdoors. An example photo is shown in Figure 8.

Figure 8 – Hydroxyl Advanced Oxidation Example Photo – (Vapex Environmental)

3.6 Technologies Comparison Summary

Table 4 outlines the advantages and disadvantages of each potential odor control technology considered as part of this memorandum.

Table 4 – Odor Control Technologies Evaluation

Technology	Advantages	Disadvantages
Adsorption	• Excellent removal efficiency for odor, H_2S and RSC removal • Equipment is technologically simple and adaptable to many treatment formats • Wide range of commercial products available • Wide variety of target contaminants	• Activated carbon adsorption can be costly on the media replacement frequency • Non-selective method • May have additional requirements based on the type of adsorbent applied • Requires regeneration or replacement of adsorbent material • Often results in rapid saturation and clogging of reactors without a dehumidification system
Biofiltration	• Moderate capital costs • Efficiently eliminates biodegradable organic matter • High removal of BOD and suspended solids • Up to 10,000 cfm are available as a modular unit	• Requires maintenance of optimal conditions for organisms • Slow process • Potential sludge production and uncontrolled degradation products • High H_2S peak loadings may cause biofilter to acidify
Bioscrubber	• High reliability and efficiency for H_2S removal • Small footprint	• Performance is dependent on operation of recirculation system • Lower removal efficiencies for RSCs • Water demand requirements for recirculation system
Biotrickling	• High reliability and efficiency for H_2S removal • Tower arrangement, small footprint	• Performance is dependent on the inlet loading • Lower removal efficiencies for RSCs • Water demand requirements since is not using a recirculation system
Photoionization (UV)	• High efficiency for odor, H_2S and RSC removal • Suitable for intermittent operation • Operates under negative pressure	• Regular maintenance to replace the UV bulbs • Ozone monitors should be installed on the exhaust
Hydroxyl Generator	• High efficiency for odor, H_2S and RSC removal • Minimal space requirements • Units are considered green technology due to small footprint, quiet and no waste products or chemicals	• Safety and environmental concerns due to possibility of unreacted radicals remaining in air stream • Typically, only used at remote facilities (pump stations) that are not occupied by staff • May require temperature control for the ambient air •
Hydroxyl Advanced Oxidation	• High efficiency for odor, H2S and RSC removal • Minimal space requirements • Units are considered green technology due to small footprint, minimal water and electricity, quiet and no waste products or chemicals	• Safety and environmental concerns due to possibility of unreacted radicals remaining in air stream • Typically, only used at remote facilities (pump stations) that are not occupied by staff • Requires H_2S monitoring system for control

4. New Odor Technologies Recommendation

As described in Section 2, odor control was considered on five (5) pump stations locations based on the sampling results. A description of each pump station and the recommended technology is described in the following sub-sections.

4.1 Pump Station #4

Pump Station #4 is located on the southern end of the Morris Forman service area. There is no existing odor control system installed at this location. The sampling results for this location, described fully in TM #6C, showed high odor values and high H_2S levels at the facility, but the H_2S levels are within MSD regulated limits. Based on both the sampling results and a review of applicable odor removal technologies, a hydroxyl generator or photoionization unit, could be considered for odor removal at this facility.

4.2 Pump Station #6

Pump Station #6 is located on the northern end of the Morris Forman service area, east of the downtown area. There is no existing odor control system installed at this location. The sampling results for this location, described fully in TM #6C, showed elevated odor levels and H_2S levels at the facility, but the H_2S levels are within MSD regulated limits. Based on the sampling results and a review of applicable odor removal technologies, either a multi-layer carbon unit or hydroxyl generator could be considered for odor removal at this facility.

4.3 Pump Station #8

Pump Station #8 is located on the northern end of the Morris Forman service area, just west of Pump Station #6. There is no existing odor control system installed at this location. The sampling results for this location, described fully in TM #6C, showed elevated odor levels and H_2S levels at the facility, along with an elevated Dimethyl Disulfide, but the H_2S levels are within MSD regulated limits. Based on both the sampling results and a review of applicable odor removal technologies, either a photoionization unit or hydroxyl advanced oxidation (VAPEX) could be considered for odor removal at this location. After final evaluations and discussions with MSD, the most economical of the three types of systems would be designed to manage the H_2S and odor levels present at the facility.

4.4 Pump Station #2

Pump Station #2 is located on the east end of the Morris Forman service area. There is an existing dual bed carbon adsorber odor control system currently installed at this facility (see TM #7C for additional details). Based on the sampling results described in TM #6C, the existing odor control system is meeting performance requirements for percent H_2S reduction, but the odor and H_2S levels are elevated. The H_2S levels are within MSD regulated limits. With elevated odor and H_2S levels, a new odor control technology is recommended to replace the existing carbon unit. At this facility, either Photoionization or a biotrickling unit are recommended to reduce the odor and H_2S levels.

4.5 Pump Station #3

Pump Station #3 is located in the center of the Morris Forman service area. There is an existing dual bed carbon adsorber odor control system currently installed at this facility (see TM #7C for additional details). Based on the sampling results described in TM #6C, the existing odor control system is meeting performance requirements for percent H_2S reduction, but the odor and H_2S levels are elevated. The H_2S levels are within MSD regulated limits. With elevated odor and H_2S levels, a new odor control technology is recommended to replace the existing carbon unit. At this facility, either a biotrickling system or a new multi-media carbon unit are recommended to reduce the odor and H_2S levels.

5. Conclusions

As described above, odor control systems are proposed to be installed at Pump Station #4, Pump Station #6, Pump Station #2, Pump Station #3, and Pump Station #8 locations. New odor control technologies are recommended to replace the current carbon systems at both Pump Station #2 and Pump Station #3. Coordination and communication are currently ongoing with vendors for the recommended technologies to determine which specific technology would be applicable at each pump station facility. Conceptual designs for the final recommended units will be developed for each location and provided as part of TM #9.