AECOM

Morris Forman WQTC Odor Control Master Plan

Final Report

Louisville and Jefferson County Metropolitan Sewer District

December 22, 2022

FINAL

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Revision	Revision date	Details	Authorized	Name	Position
0	12-13-2021	Interim Final Report	Yes	Amanda Foote	Project Manager
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Acronyms and Abbreviations

Acronym/ Abbreviation	Description
APCD	Louisville Metro Air Pollution Control District
ARV	Air Relief Valve
ASTM	American Society for Testing and Materials
BOC	Biological Odor Control
BOD5	Biological Oxygen Demand
CFR	Code of Federal Regulations
DAFT	Dissolved Air Flotation Thickener
DO	Dissolved oxygen
D/T	Dilution-to-Threshold
EPA	Environmental Protection Agency
H_2S	Hydrogen sulfide
ITB	Invitation to Bid
m	Meter
MFWQTC	Morris Forman Water Quality Treatment Center
m3/s	Cubic meters per second
MEB	Main Equipment Building
MGD	Million gallons per day
MSD	Louisville and Jefferson County Metropolitan Sewer District
NOV	Notice of Violation
OCMP	Odor Control Master Plan
ORFM	Ohio River Force Main
ORI	Ohio River Interceptor
OSHA	Occupational Safety and Health Administration
ou	Odor unit
PM	Particulate matter
ppb	Parts per billion
ppm	Parts per million
PRV	Pressure Relief Valve
PS	Pump Station
RSC	Reduced Sulfide Compound
RTO	Regenerative Thermal Oxidizers
SHOC	Solids Handling Odor Control
TM	Technical Memorandum
TRS	Total Reduced Sulfur
TUC	Truck Unloading Station

VOC	Volatile Organic Compound
WEA	Webster Environmental Associates
WWTF	Wet Weather Treatment Facility
WQTC	Water Quality Treatment Center

1. Executive Summary

1.1 Background

In response to receiving a Notice of Violation (NOV) in November 2019 for failure to control odors from the Morris Forman Water Quality Treatment Center (WQTC, Plant) 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 Technical Services Inc. (AECOM) to provide MSD with professional engineering services for the development of the Odor Control Master Plan (Odor Control Master Plan), which is focused on the Morris Forman WQTC, Morris Forman Collection System, and selected pump stations within 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 Odor Control Master Plan.

An Initial Draft Report was developed to document the initial phases of the phased Odor Control Master Plan with primary focus on the Morris Forman WQTC and its service area. The initial draft report was submitted to MSD December 13, 2021. This updated version of the report (Final Report) has been developed following the completion of ongoing odor control improvements at the Morris Forman WQTC and the second phase of the Morris Forman WQTC Sampling Program.

1.2 Odor Control Master Plan Development

In accordance with the agreed order, MSD has submitted several technical memoranda to demonstrate ongoing odor control efforts. This Final Report was developed to summarize relevant information included in Technical Memoranda Nos. 1 through 9 (Table 1-1) in preparation of the development of a preferred odor control design concept for the Morris Forman WQTC, collection system, and selected pump stations. The main objectives of this Report are to:

- Identify specific odor sources at the Morris Forman WQTC, collection system, and selected pump stations that may contribute to nuisance conditions;
- Conduct liquid and vapor sampling at critical process areas;
- Characterize and evaluate the performance for existing odor control systems and odor control technologies; and
- Investigate potential odor control solutions and treatment technologies required to meet the overall design criteria established by MSD.

Development of the Odor Control Master Plan included liquid and vapor sampling throughout the Plant, collection system, and selected pump stations to assess existing odor conditions at critical areas in the Morris Forman Service Area from 2020-2022. Phase 1 of the Morris Forman Service Area Sampling Program began in August 2020 at the WQTC sedimentation basins. In 2021, sampling was performed at a Wet Weather Treatment Facility (WWTF), Morris Forman Water Quality Treatment Center (MFWQTC) headworks, MFWQTC digester, the Pump Station #5, and at eight (eight) locations in the collection system. Sampling was continued in 2022 at the MFWQTC Dissolved Air Flotation Thickener (DAFT) outlet, dewatering building exhaust, silo dust wet scrubber, Regenerative Thermal Oxidizers (RTOs), Main Equipment Building (MEB) exhaust, fugitive dust wet scrubber, at six (6) selected pump stations, and at four (4) locations in the collection system. These sampling results were used to identify and evaluate potential odor control improvements.

Existing odor control technologies in the Morris Forman Service Area were characterized and evaluated for current odor treatment performance. A detailed review of potential odor control technologies was also performed in preparation of the development of plant-wide odor control alternatives.

1.3 Implementation Schedule

The Phase I Odor Control Master Plan Implementation Schedule has been developed to document MSD's completed and ongoing efforts towards the APCD agreed order.

Table 1-1 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	Completed
TM#9	Odor Control Conceptual Design	Q4 2022	Completed
Odor Control Master Plan Phase I Final Report		**Q4 2022**	**Completed**

New additions to this report include the following sections:

- Morris Forman WQTC Phase 2 Sampling Results
- Collection System Phase 2 Sampling Results
- Pump Station Phase 2 Sampling Results

- Current Odor Technologies Evaluation at MFWQTC:
- Current Odor Technologies Evaluation in the collection system:
- Current Odor Technologies Evaluation at selected pump stations:
- Dispersion Modelling
- Odor Control Design Alternatives

2. Introduction

2.1 Background

In response to receiving a Notice of Violation (NOV) in November 2019 for failure to control odors from the Morris Forman Water Quality Treatment Center (WQTC, Plant) and its collection system, Louisville and Jefferson County Metropolitan Sewer District (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 which will be completed in multiple phases over the course of several years. 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.

The Morris Forman Service Area extends across approximately 134 square miles in Jefferson County, Kentucky. Wastewater throughout the service area is collected and conveyed by approximately 1,910 miles of sewer to the Morris Forman Water Quality Treatment Center (WQTC, Plant) for subsequent treatment. There are currently thirteen main gravity trunk sewers, two major force mains, and 139 pump stations in the MFWQTC Service Area. The plant, constructed and commissioned in 1958, is currently the largest wastewater treatment plant in the state of Kentucky. Located in the western region of Louisville along the Ohio River, the plant is responsible for treating 120 MGD of dry weather flow and a peak capacity of 350 MGD during wet weather flow conditions.

Despite recent efforts by MSD to reduce odor emissions generated in the Morris Forman Service Area through development and phased implementation of the 2001 Morris Forman Odor Control Master Plan and 2009 follow-up report, the neighboring community has experienced 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.

2.2 Purpose and Implementation Schedule

The purpose of this Final Report is to summarize the findings and recommendations to date under Phase I of MSD's Odor Control Master Plan with primary focus on odor mitigation in the Morris Forman Service Area.

In accordance with the agreed order, MSD has submitted nine (9) technical memoranda throughout Phase I of the Odor Control Master Plan to demonstrate their continued odor control efforts. Table 2-1 summarizes the implementation schedule developed to meet the agreed order including each deliverable title and submittal date. These technical memoranda were released periodically to APCD and posted to the MSD website for public use.

Table 2-1 Phase I Master Plan Implementation Schedule

Title		Date Submitted*
TM#1	Morris Forman WQTC Background Document Review	2/16/2021
TM#2	Collection System Background Document Review	4/7/2021
TM#3	Pump Stations Background Document Review	5/4/2021

TM#4	WQTC, Pump Stations and Combined Sewer System Planned Process Modifications	3/23/2021
TM#5	Current WQTC, Pumping Stations and Combined Sewer System Odor Impact Evaluation	6/21/2021
TM#6A, TM#6B, TM #6C	Morris Forman WQTC (TM#6A), Collection System (TM #6B), and Pump Stations (TM #6C) Sampling Phase Results Analysis	12/13/2022 12/13/2022 12/13/2022
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	12/13/2022 12/13/2022 12/13/2022
TM#8	New Odor Control Technologies Recommendation	12/14/2022 12/14/2022 12/14/2022
TM#9	Odor Control Conceptual Design	12/19/2022
Odor Control Master Plan Phase I Final Report		**12/22/2022**

**-The dates referenced refer to the latest submitted version. Some technical memoranda were submitted multiple times with informational updates in each submittal. Only the latest submitted date is represented.*

This Final Report summarizes the information included in Technical Memoranda Nos. 1 through 9, and it presents the findings to date under Phase I of the Odor Control Master Plan.

2.3 Background Documentation Review

Prior to the development of this report, AECOM performed a detailed review and analysis of existing documentation related to odor control at the Morris Forman WQTC, collection system, and pump stations. Background documentation included previous studies, reports, field sampling and performance testing data to gain an understanding of MSD's odor control efforts to date and to investigate current odor conditions in specific process areas. Key findings of the background documentation review process can be found in TM#1 for the Morris Forman WQTC, TM#2 for the Morris Forman Collection System, and TM#3 for the Morris Forman Pump Stations.

2.3.1 Morris Forman WQTC Review

In 2001, MSD contracted two consultants to perform an odor control evaluation of the Morris Forman WQTC. The report, which is referred to as the 2001 OCMP, provided a phased approach to odor mitigation at the WQTC, including recommended operational adjustments, improvements to the Biotower odor control system, and installation of a dedicated odor control system at the Headworks and Aerated Influent Channel. The estimated capital cost for a Headworks odor control system was $1.67 Million, in 2001 dollars, with the assumption that biofiltration was the selected odor control technology.

In 2009, a follow-up report was developed which documented the completion of the control improvements listed above and re-evaluated the initial OCMP implementation strategy based on updated sampling and dispersion modeling results. MSD is currently in the process of implementing odor control projects identified as part of the 2009 planning study, including the rehabilitation of the Sedimentation Basins. Table 2-2 shows the completion status of major odor control projects identified in previous planning reports.

Table 2-2 Summary of Completed and Ongoing Odor Control Projects

Description		Year(s) Completed
1	Replacement of fume incinerators with Solids Handling Odor Control (SHOC)	2006; Rebuilt in 2011
2	Screw Conveyer improvements at the Main Equipment Building	2006
3	Digester valving improvements	2006
4	Replacement of existing chemical scrubbers with Biological Odor Control (BOC)	2007
5	Upgrades to the existing grit channel covers	2008
6	Upgrades to MEB odor control systems including replacement of sludge dryer system, Regenerative Thermal Oxidizers (RTOs), main process wet scrubber, and fugitive dust wet scrubber	2022
7	Control of Primary Clarifier and Aerated Influent Channel Emissions	Aerated Influent Channel Emissions - 2010 Primary Clarifier - Ongoing

As part of the document review process, AECOM compiled and evaluated available field sampling and testing data related to odor conditions and odor control system performance at the WQTC. Completion dates spanned from 2001 to 2020. Available sampling data included gas and liquid phase sampling for odor concentration, reduced sulfide compound (RSC) concentrations, and hydrogen sulfide (H_2S) monitoring at specific locations throughout the WQTC. Table 2-3 summarizes the available background data provided by MSD for initial evaluation purposes.

Table 2-3 WQTC Background Data Summary

Testing Description and Location		Date(s) Completed
Field Sampling		
1	Gas and liquid phase sampling and H_2S monitoring at (14) process area locations	2001
2	Gas sampling and H_2S monitoring at the Main Equipment Building (MEB), Dissolved Air Floatation Thickener (DAFT), Truck Unloading Station (TUS), and Digester Pressure Relief Valves (PRVs)	2007
3	Gas and liquid phase sampling and H_2S monitoring at (26) process area locations	July-August 2008
4	Gas and liquid phase sampling and H_2S monitoring at Sedimentation Basins and Aerated Influent Channel	September 2020

Performance Testing

1	Biological Odor Control (BOC) Performance Testing	September 2008
2	Solids Handling Odor Control (SHOC) Performance testing	July-September 2008; November 2012; April 2013

For further details regarding WQTC background documentation, please refer to TM#1.

2.3.1.1 MFWQTC Existing System Configuration

The Morris Forman WQTC began operations in 1958 and is classified as a conventional extended aeration activated sludge process plant. The Plant is currently equipped to treat 120 MGD of dry weather flow and 350 MGD of wet weather flow in addition to solids handling processing abilities. Each major process area is further discussed within this Section.

2.3.1.1.1 Primary Treatment Facilities

Raw wastewater is conveyed to the Plant Influent Junction structure through the Ohio River Interceptor and Southwestern Branch Interceptor before entering the Headworks. The WQTC is currently equipped with two (2) Headworks facilities. The East Headworks is the primary headworks facility, and the West Headworks is used for wet weather flows. The West Headworks is original to the 1958 Plant and is equipped with a dedicated screening facility, grit removal via the West Grit Channel, aeration system, and drainage pumping.

In 1998, MSD installed the East Headworks, and upgraded in 2018, as the primary facility. The East Headworks takes in raw wastewater via Parshall Flumes prior to the screening and grit removal process. After passing through the East Headworks Grit Channel, screened wastewater enters the Aerated Influent Channel.

The screenings and grit removed from the raw wastewater are transferred via belt conveyors to containers for hauling to a commercial landfill. The partially treated wastewater flows through the Aerated Influent Channel into four (4) rectangular Sedimentation Basins, also referred to as Primary Clarifiers. The settled solids are removed from the bottom of the Sedimentation Tanks by scrapers supported from carriages moving on rails. The monorake mechanism also skims floating material (scum) from the surface of the wastewater in the sedimentation tanks. The raw primary sludge is pumped from hoppers in the ends of the sedimentation tank floors to four (4) anaerobic digesters. Collected scum is also pumped to the digesters.

2.3.1.1.2 Secondary Treatment Facilities

Secondary treatment facilities include five (5) oxygenation trains operated in parallel and twenty (20) final settling tanks, or Secondary Clarifiers. The WQTC is rated for a secondary treatment capacity of 120 MGD and an increasingly reduced performance up to a flow of 140 MGD. All discharge flow from the primary system in excess of 140 MGD and up to 350 MGD bypasses the secondary system and is conveyed directly into the Chlorine Contact Chambers.

In the 1970s, oxygenation trains were added to the secondary treatment system to provide extended aeration to primary effluent from the Sedimentation Basins. Each oxygenation train consists of four (4) successive aeration chambers. Oxygen gas and return sludge are added to the wastewater in the first chamber of each train. Each aeration chamber is also equipped with a mixer to provide suspension of solids. A new oxygen system replaced the original system in 2018.

Mixed liquor effluent from the oxygenation trains flow into the Secondary Clarifiers where flow is distributed equally between each clarifier. Settled sludge from the clarifiers is recycled to the oxygenation trains or wasted to the sludge thickeners.

The Chlorine Contact Chambers consist of two (2) flow chambers and may be operated using either the single or dual chambers. The dual chambers provide a minimum contact period of 11 minutes at the peak flow rate of 350 MGD. Disinfection of the flow is accomplished by injecting a solution of sodium hypochlorite (bleach) into the secondary effluent. Dechlorination is performed by the addition of sodium bisulfite prior to discharging the effluent to the Ohio River.

2.3.1.1.3 Solids Handling Facilities

Primary sludge undergoes biological treatment via four (4) anaerobic digesters. Waste activated sludge is thickened by eight (8) Dissolved Air Flotation Thickening (DAFT) units housed in the Main Equipment Building (MEB). Five (5) high-speed solid bowl centrifuges are used to dewater the thickened waste activated sludge and digested primary sludge. The treated and dewatered sludge is processed through two rotary drum dryers and distributed for beneficial use.

2.3.1.1.4 Laboratory Facilities

The Plant maintains a fully staffed on-site laboratory for the daily analysis of process control and compliance samples. The laboratory is also responsible for analysis of industrial and commercial effluents sampled by MSD's Industrial Compliance and Monitoring Department.

2.3.1.1.5 Effluent

The hydraulic design of the Plant allows for treated effluent to enter the outfall sewer in the floodwall and flow by gravity into the Ohio River during river level conditions equal to or less than the normal river elevation of 390 feet. When the river level reaches approximately 402 feet, it becomes necessary to pump the final effluent over the levee into the river via the Final Effluent Pump Station (FEPS).

2.3.1.2 Existing Odor Control Systems

To mitigate odor emissions from the process areas listed above, MSD currently operates several odor control systems at the WQTC which are summarized below.

- Solids Handling Odor Control (SHOC) – Installed in 2006 and rebuilt in 2011, the SHOC system was designed to replace the fume incinerators for treatment of foul air from the Main Equipment Building and Sludge Holding Tanks. One of the existing fume incinerators remained as a backup to the SHOC system until 2007 when it was decommissioned.
- Biotower Odor Control (BOC) – The Plant's BOC system was upgraded in 2007 to replace the original chemical scrubbers serving the Bioroughing towers. The existing BOC system treats foul air from the Aerated Influent Channel. The Bioroughing Towers are not currently in service.
- Regenerative Thermal Oxidizers (RTOs) – The existing RTO units are used to reduce VOCs in the air from the MEB dryer system and were recently replaced under the Emergency Dryer Replacement project. The MEB drying system operates under negative pressure which allows the collection and treatment of foul air through the RTOs. The RTO system consists of two (2) identical RTOs manufactured by Gulf Coast Environmental Systems. Each RTO has a dedicated exhaust fan, dryer train, and air duct.
- MEB Main Process Wet Scrubbers – The MEB is currently equipped with two (2) venturi scrubbers designed to treat dust streams produced during the sludge dewatering and drying process. These scrubbers are housed on the 6th floor of the MEB.

- MEB Acid Scrubbers – The MEB is currently equipped with two (2) acid scrubbers designed to remove ammonia immediately following the venturi scrubbers; however, these units are currently only operating as a pass-through.
- MEB Fugitive Dust Wet Scrubbers – Two (2) Fugitive Dust Wet Scrubbers are located in the MEB and treat fugitive dust from the solids recycling bins, crushers, screeners, and pellet coolers.
- MEB Silo Wust Wet Scrubber – One (1) Wet Scrubber is located in the MEB and treats fugitive dust from the MEB solids storage silos.

2.3.2 Morris Forman Collection System Review

The Morris Forman combined sewer collection system serves approximately 134 square miles across Jefferson County, Kentucky. Wastewater throughout the service area is collected and conveyed by approximately 1,910 miles of sewer to the MFWQTC for subsequent treatment. There are currently thirteen (13) main gravity trunk sewers, (2) major force mains, and 139 pump stations in the MFWQTC service area. Figure 2-1 shows an overview of the MFWQTC collection system including service area boundaries, pump stations, major gravity trunk sewers, force mains, and the location of MFWQTC.

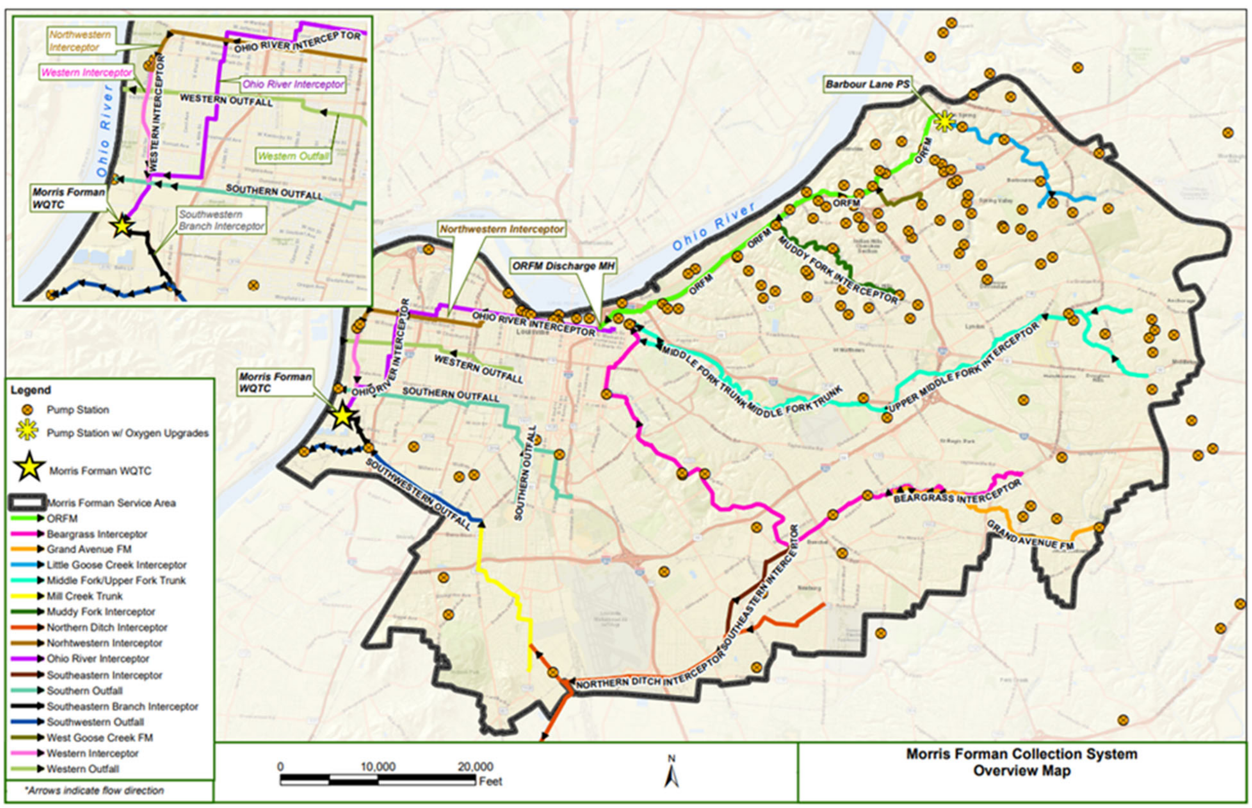

Figure 2-1 MFWQTC Collection System Overview

MSD has made several odor control improvements within the collection system. Beginning in April 2014, MSD contracted a third party firm to perform routine chemical dosing at various locations. To assess the odor removal efficiency of chemical dosing, gaseous hydrogen sulfide (H_2S) and liquid nitrate sampling were also performed each quarter. MSD has continued chemical dosing and monitoring within the collection system as outlined in the MSD Collection System Calcium Nitrate Solution Supply and Odor Control Service Bid.

In March 2018, MSD contracted a consultant to perform an odor evaluation on the Ohio River Force Main (ORFM) air relief valve (ARV) locations in the northeast portion of the Morris Forman Service Area. Multiple improvements were implemented as a result of this study. These improvements included:

1. Installation of biofilter system at an ARV (2018)
2. Closure of the smaller diameter barrel on a portion of the ORFM (2018)
3. Construction of an oxygen injection system at a pump station (PS) (2021)

As part of the document review process, AECOM compiled and evaluated available field sampling and testing data related to odor conditions and odor control system performance in the collection system. Table 2-4 summarizes the available background data provided by MSD for initial evaluation purposes.

Table 2-4 Collection System Background Data Summary

Testing Description and Location		Date(s) Completed
Field Sampling		
1	Gaseous H_2S monitoring at nine locations in the ORFM	April-May 2017
Performance Testing		
1	Bioxide Injection Performance testing	April 2014-December 2020
2	ARV Biofilter Performance testing	August-October 2017
3	PS Oxygen System Performance testing	March-June 2021

For further details regarding the collection system background documentation, please refer to **TM#2**.

2.3.2.1 Collection System Existing Odor Control

To mitigate odor emissions in the collection system, MSD currently operates several odor control systems which are summarized below.

- Bioxide injection – Five (5) locations within the collection system are injected with Bioxide since April 2014.
- Biofilter – A biofilter was installed in 2017 and is currently operating at an ARV.
- Oxygen injection system – An oxygenation system was installed at a PS in 2021.

2.3.3 Morris Forman Pump Station Review

Seven (7) pump stations and one (1) wet weather treatment facility were selected for evaluation as part of the Odor Control Master Plan development. Pump station selection was based on historical community odor impacts after discussions with MSD. A summary of the selected pump stations is listed below.

1. Wet Weather Treatment Facility #1
2. Pump Station #2
3. Pump Station #3

4. Pump Station #4
5. Pump Station #5
6. Pump Station #6
7. Pump Station #7
8. Pump Station #8

Of the seven (7) selected pump stations, only three (3) are currently equipped with odor control technologies for the treatment of odorous air. These three (3) were Pump Station #5, Pump Station #2, and Pump Station #3, and a summary of their existing odor control technologies is shown in Table 2-5, including installation year.

Table 2-5 Pump Station Background Data Summary

Odor Technology Implementation and Sampling Location Summary		Date(s) Completed
Field Sampling		
1	Gaseous H_2S monitoring at PS #5	June-July and October 2020
Odor Technology Implementation		
1	PS #5 Dual-Bed Carbon Adsorber	2013
2	PS #2 Dual-Bed Carbon Adsorber	2017
3	PS #3 Dual-Bed Carbon Adsorber	2013 (Updated in 2018)

Performance testing for these technologies was included as a part of the Odor Control Master Plan sampling campaign in 2021-2022. For further details regarding the pump station background documentation, please refer to **TM#3.**

2.3.3.1 Pump Station Existing Odor Control

To mitigate odor emissions in pump stations within the Morris Forman Service Area, MSD currently operates the following odor control systems summarized below.

- PS #5 Dual-Bed Carbon Adsorber – A virgin activated carbon dual-bed carbon adsorber was installed in 2013 to treat odor from the Influent Chamber, Screen Channels, Screen Room, Pipe Gallery, and Wet Wells.
- PS #2 Dual-Bed Carbon Adsorber – A high-capacity activated carbon and virgin coconut shell activated carbon dual-bed carbon adsorber was installed in 2017 to treat odor from the Wet Well, Screen Channels, Screen Room, and Dumpster Area.
- PS #3 Dual-Bed Carbon Adsorber – An enhanced virgin coconut shell activated carbon dual-bed carbon adsorber was installed in 2013 and updated in 2018 to treat odor from the Wet Well, Inlet Channel, Screen Room, and Dumpster Area.

2.4 Design Basis and Objectives

The overall purpose of this Odor Control Master Plan is to provide site-specific, cost-effective odor controls which will reduce odor emissions from major odor sources in the Morris Forman

Service Area and meet the desired odor detection threshold of 20 D/T at critical receptors within the surrounding community.

The Odor Control Master Plan evaluated a reasonable range of operational and chemical treatment alternatives required to meet the design criteria. Affordability, odor removal performance, and implementation requirements were considered to help guide the selection of the preferred alternatives. In addition, public and regulatory agency input were considered during development of alternatives.

The following key tasks were performed as part of this Master Plan:

1. Identification of specific odor sources that may contribute to nuisance conditions;
2. Evaluation of current performance for existing odor control systems and technologies;
3. Preparation and implementation of a vapor and liquid sampling program to evaluate current odor impacts at specific process areas;
4. Investigation of potential odor control solutions and treatment technologies required to meet the overall design criteria established by MSD;
5. Determination of recommended design parameters for existing and future odor treatment technologies;
6. Construction and utilization of an updated air dispersion model to assess odor impacts based on predicted emissions and meteorological data; and
7. Development of final selected odor control alternatives to be considered for implementation.

2.5 Community Issues

The Morris Forman WQTC is located in a mixed industrial/residential area of Metro Louisville. Several industrial properties are located adjacent to the Plant including Valero, Buckeye Terminals, Whayne Trucks, and the Firearms Training Center. The Park DuValle residential neighborhood is located about 0.7 miles to the east, and the Chickasaw neighborhood is located about 0.5 miles to the north.

An overview map of the Morris Forman WQTC is provided in Figure 2-2 and identifies customer odor complaint locations, MSD-owned property boundaries, and adjacent properties which may potentially be impacted by Plant odor emissions.

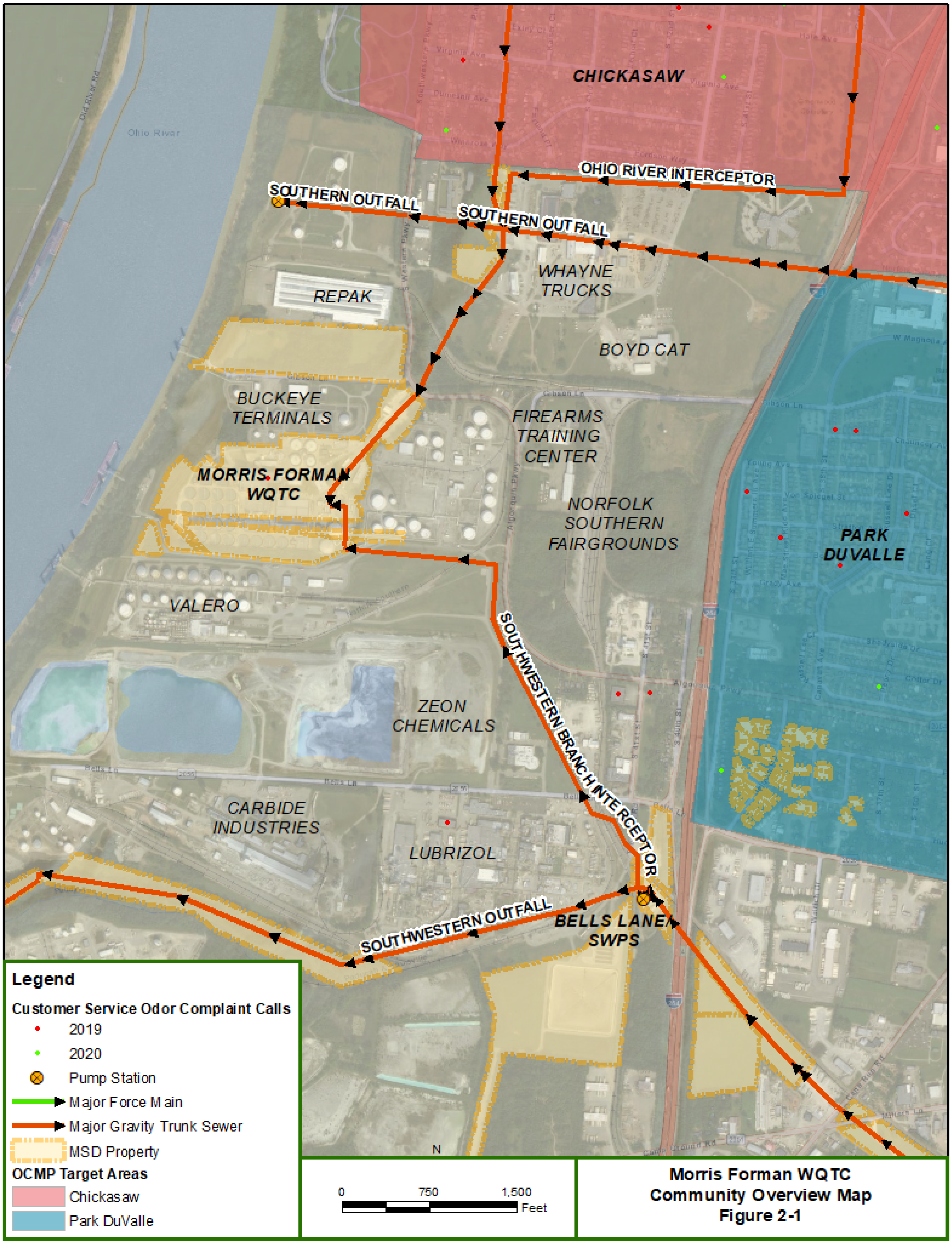

Figure 2-2 Morris Forman WQTC Community Overview Map

2.6 Public Engagement and Communications

MSD contracted a public relations firm to increase public engagement and communications during development and implementation of the phased Odor Control Master Plan. In 2021, MSD launched the “clAIRity” Program which is a proactive odor control initiative designed to reduce sewer and wastewater treatment odors across the system. A webpage for the clAIRity Program is published onto MSD’s website and includes the following:

- Informational brochures and procedures related to odor emissions and proactive control measures;
- Access to the monthly odor complaint log, Odor Control Communication Plan, and technical memoranda developed under this Odor Control Master Plan; and
- Updates on MSD’s odor control efforts through community meetings.

3. Sampling Program

Findings from the background documentation review process were consolidated to establish a comprehensive list of potential odor sources and associated priority ratings. TM#5 discussed the results of the priority rating process based on previous sampling data, proximity to identified odor hot spots, and current operation status. Using the findings of the odor impact evaluation, high priority odor sources were selected for inclusion into a sampling program.

3.1 MFWQTC Sampling Program

Major odor-emitting processes at the Morris Forman WQTC were targeted for a liquid and vapor sampling program to determine the existing odor conditions at process areas. Sampling procedures were developed and implemented to evaluate the concentration of relevant contaminants from existing infrastructure, recently implemented infrastructure which has not been evaluated in detail, and infrastructure that is currently under development or considered for future development.

The Morris Forman WQTC Sampling Program consisted of (2) phases:

- Phase 1 – Existing Process Areas: June 14, June 15, and June 22, 2021
- Phase 2 – Improved Process Areas: March 7, May 17, May 18 July 27, and August 18. 2022

Phase 1 involved sampling of existing odor processes, and Phase 2 was performed following the completion of ongoing and future odor control improvements including SHOC upgrades, BOC system upgrades, and process improvements under the Emergency Dryer Replacement project.

Samples were obtained when odor control systems and related equipment were fully operational. For sampling locations with quiescent surfaces, a surface emission flux chamber was used, and sweep air was added to the chamber at a controlled, fixed rate. A vacuum chamber, pump and Tygon tubing was used at point sources to prevent contamination of air samples. Liquid sampling was performed by MSD staff, and vapor sampling was contracted to a third-party contractor. Liquid and vapor samples were quantified by third-party laboratories.

Specific sampling parameters are listed for each sampling location in Table 3-1. Refer to TM#6A for additional details from the Morris Forman WQTC Sampling Program.

Table 3-1 MFWQTC Sampling Overview

Sample ID	Location	Description	Date(s) of Sampling
B1	WWTF #1	Splitter Structure #2	9/22/2021
B2	WWTF #1	HRTB Influent	9/22/2021
B3	WWTF #1	Grit Dumpster	9/22/2021
B4	WWTF #1	Grit Tank Influent	9/22/2021
1	MFWQTC	DAFT Outlet	3/7/2022
2A	MFWQTC	East Headworks 1st Floor	6/14/2021
2B	MFWQTC	East Headworks 2nd Floor	6/14/2021
3	MFWQTC	West Headworks	6/14/2021
4A	MFWQTC	East Headworks Grit Channel	6/14/2021
4B	MFWQTC	West Headworks Grit Channel	6/14/2021
5	MFWQTC	Dumpster Room	6/14/2021
6	MFWQTC	SHOC Bioscrubber Inlet	-
7A	MFWQTC	SHOC Bioscrubber #1 Outlet	-
7B	MFWQTC	SHOC Bioscrubber #2 Outlet	-
8	MFWQTC	Thickened Solids Holding Tank	-
9	MFWQTC	Digester	6/14/2021
10	MFWQTC	Dewatering Building Exhaust	8/18/2022
11	MFWQTC	Silo Dust Wet Scrubber Inlet	-
12	MFWQTC	Silo Dust Wet Scrubber Outlet	5/18/2022
13A	MFWQTC	RTO #1 Inlet	5/17/2022
13B	MFWQTC	RTO #2 Inlet	7/27/2022
14A	MFWQTC	RTO #1 Outlet	5/17/2022
14B	MFWQTC	RTO #2 Outlet	7/27/2022
15	MFWQTC	Fugitive Dust Wet Scrubber #1 Inlet (From Recycle Bin)	-
16	MFWQTC	Fugitive Dust Wet Scrubber #2 Inlet (From Shaker, Crusher, and Pellet Coolers)	-
17A	MFWQTC	Fugitive Dust Wet Scrubber #1 Outlet	5/18/2022
17B	MFWQTC	Fugitive Dust Wet Scrubber #2 Outlet	7/27/2022
18	MFWQTC	MEB Exhaust	8/18/2022
U1	MFWQTC	Sed. Basin Aerated Influent Channel	9/30/2020
U2	MFWQTC	Sed. Basin #1 Inlet	9/30/2020
U3	MFWQTC	Sed. Basin #1 Outlet	9/30/2020
U4	MFWQTC	Sed. Basin #1 Weir	9/30/2020
U5	MFWQTC	Sed. Basin #4 Inlet	9/30/2020
U6	MFWQTC	Sed. Basin #4 Outlet	9/30/2020
U7	MFWQTC	Sed. Basin #4 Weir	9/30/2020
U8	MFWQTC	Sed. Basin Eff. Channel	9/30/2020

U9	MFWQTC	BOC Inlet	-
U10	MFWQTC	BOC Outlet	-

3.1.1 Collection System Sampling Program

Initially, the Morris Forman Collection System Sampling Program included thirteen (13) sampling locations. Sampling locations were selected based on odor complaints which showed relatively high odor impacts – specifically within the Chickasaw, Shawnee, California, and Park DuValle neighborhoods. These locations were further evaluated in Fall of 2021 and narrowed down to eight (8) locations for inclusion in the first phase of the Morris Forman Collection System Sampling Program. The second phase included 4 additional sites that were sampled in May of 2022, for a total of 12 sampling locations.

Sampling parameters included in the Morris Forman Collection System Sampling Program were the same as those for the MFWQTC Sampling Program and are summarized in TM #6B. A summary of the sampling program locations and characteristics is shown in Table 3-2 and an overview map of the sampling locations is shown in Figure 3-1. Liquid sampling and vapor sampling was contracted to a third-party contractor, and liquid and vapor samples were quantified by third-party laboratories.

Note that the catch basin sampling locations (2, 8, and 14) did not include H_2S monitoring. Refer to TM#6B for detailed sampling results from the Morris Forman Collection System Sampling Program.

Table 3-2 Collection System Sampling Overview

Sample ID	Location Description	Adjacent Neighborhood(s)	Sampling Type	Date(s) of Sampling
1	Northwestern Interceptor	Shawnee	Vapor & Liquid	10/12/21- 10/14/2021
2	Northwestern Interceptor	Shawnee	Vapor	10/12/21- 10/14/2021
3	Northwestern Interceptor	Shawnee	Vapor & Liquid	5/11/2022
4	Western Outfall	Chickasaw	Vapor & Liquid	10/12/21- 10/14/2021
5	Western Outfall	Chickasaw	Vapor & Liquid	5/11/2022
6	Ohio River Interceptor	Chickasaw	Vapor	10/12/21- 10/14/2021
7	Southern Outfall	Park DuValle/ Chickasaw	Vapor & Liquid	10/12/21- 10/14/2021
8	Southern Outfall	Park DuValle/ Chickasaw	Vapor	10/12/21- 10/14/2021
11	Western Outfall	California	Vapor & Liquid	5/11/2022
12	Western Outfall	California	Vapor & Liquid	10/12/21- 10/14/2021
13	Western Outfall	California	Vapor & Liquid	5/11/2022
14	Southern Outfall	Park DuValle	Vapor	10/12/21- 10/14/2021

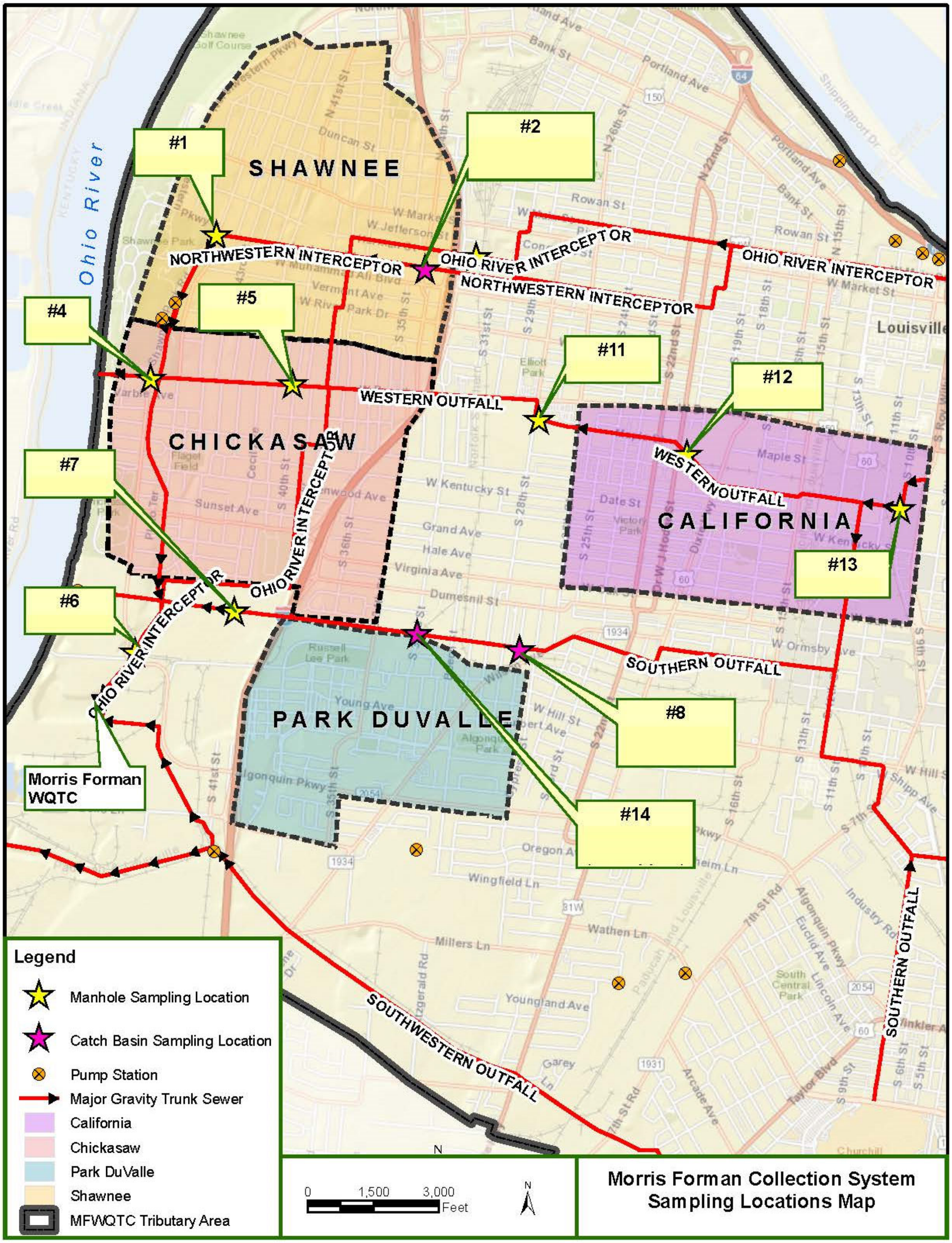

Figure 3-1 Collection System Sampling Locations Map

3.1.2 Pump Station Sampling Program

Pump station sampling locations were selected based on discussions with MSD staff and findings from the previous odor impact evaluation. High-priority odor sources in three (3) locations at PS #5 were sampled in September 2021 for Phase 1 of the sampling program. Liquid sampling in Phase 1 was performed by MSD staff, and vapor sampling was contracted to a third party.

Sampling of additional high-priority and moderate-priority odor source locations were performed at six (6) locations at selected pump stations in June 2022 for Phase 2 of the sampling program. These structures were selected for vapor sampling based on recommendations from MSD staff and odor impact ratings determined in previous TM#5. Vapor sampling in Phase 2 was contracted to a third-party consultant.

Sampling parameters included in the Morris Forman Pump Station Sampling Program were the same as those for the MFWQTC Sampling Program and are described further in TM #6C. A summary of the sampling program locations and characteristics is shown in Table 3-3, and an overview map of the sampling locations is shown in Figure 3-2. Figure 3-2 also shows the location of a manhole from the Morris Forman Collection System liquid sampling which was used to verify assumptions for the pump station liquid sampling results.

Table 3-3 Pump Station Sampling Location Summary

Sample ID	Location	Description	Odor Control System	Date of Sampling	Sample Type	
					Vapor	Liquid
S1	PS #5	Dumpster Room	Carbon Adsorber (2013)	9/13/2021	✓	✓
S2	PS #5	Splitter Structure #1		9/13/2021	✓	✓
S3	PS #5	Influent Junction Structure		9/13/2021	✓	✓
F1	PS #8	Lower Level	None	6/28/2022	✓	
F2	PS #8	Roof Exhaust	None	6/28/2022	✓	
ST1	PS #6	Lower Level	None	6/28/2022	✓	
ST2	PS #6	Roof Exhaust	None	6/28/2022	✓	
G1	PS #2	Carbon Inlet	Carbon Adsorber (2017)	6/21/2022	✓	
G2	PS #2	Carbon Outlet		6/21/2022	✓	
N1	PS #3	System 1 Inlet	Carbon Adsorber (2013; Updated in 2018)	6/21/2022	✓	
N2	PS #3	System 1 Outlet		6/21/2022	✓	
N3	PS #3	System 2 Inlet		6/21/2022	✓	
N4	PS #3	System 2 Outlet		6/21/2022	✓	

ND1	PS #4	Lower Level	None	6/22/2022	✓
U1	PS #7	Wet Well Room	None	6/22/2022	✓
U2	PS #7	Bar Screen Channel Exhaust	None	6/22/2022	✓

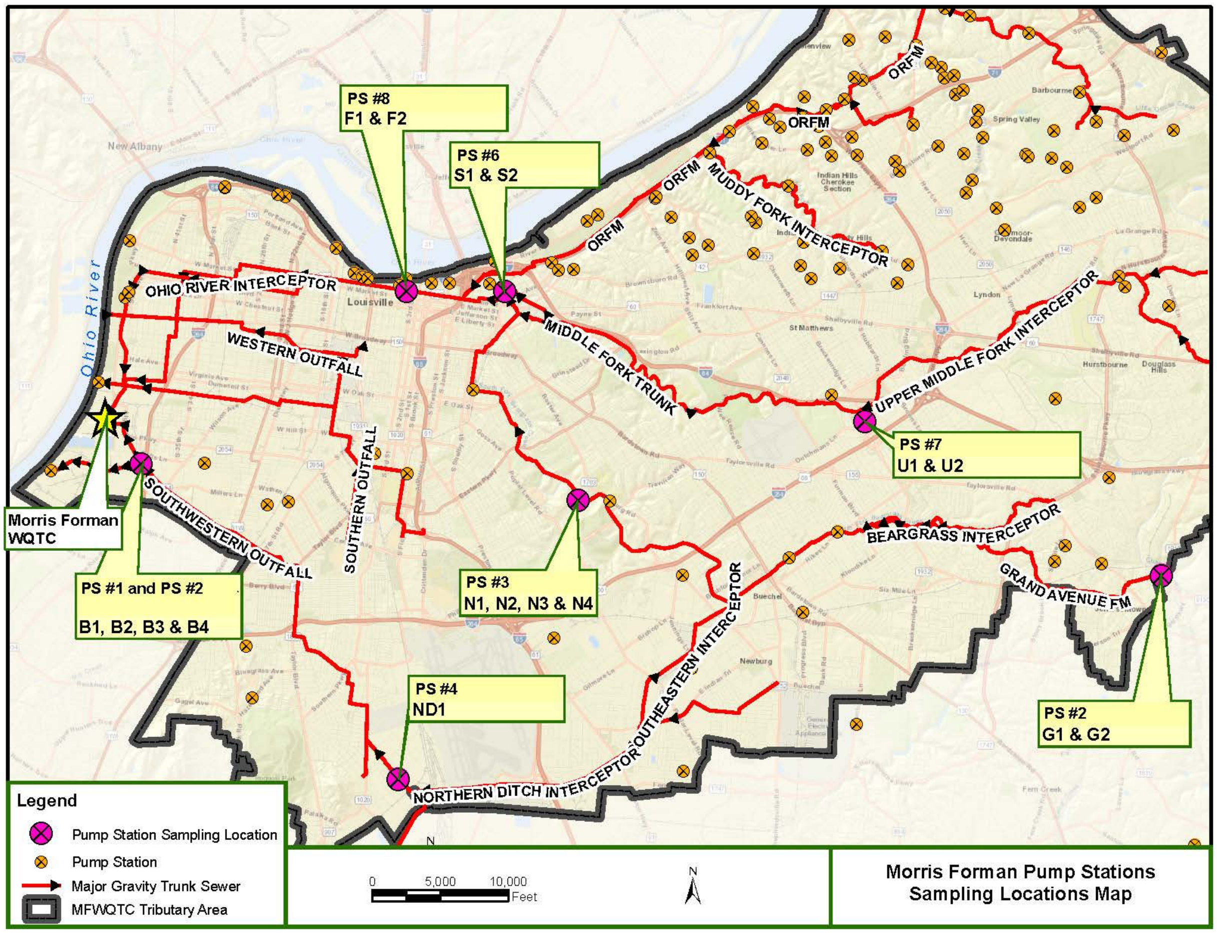

Figure 3-2 Pump Station Sampling Locations Map

3.2 Sampling Results

Table 3-4, Table 3-5, and Table 3-6 were developed to summarize the sampling results from WWTF #1, MFWQTC, selected areas of the collection system, and selected pump stations. Values are reported as low or high. If the sampling location showed both non-detect (ND) and detectable values, the values were averaged by replacing the ND value with the minimum reporting limit.

Target thresholds were assigned to each analyte based on various regulatory standards and guidelines. MSD is only required to meet the liquid discharge regulations and the APCD standard for gaseous H_2S concentrations at the source. Additional workplace and environmental standards were used to identify elevated concentrations of other odorous compounds, but these were used as a reference for comparison only. For analytes without required exposure limits, available guidelines and mean air odor detection thresholds were utilized to assign a target limit. Red text indicates instances where sampling results exceeded target limits at the odor sources, and the specific wastewater/odor compounds shown in these tables were elevated in at least one sampling location. Additional sampling data is provided in TM#6A, TM#6B, and TM#6C.

Table 3-4 WWTF #1 and MFWQTC 2020-2022 Sampling Results

ID	Location	Odor** (D/T)	H_2S (ppm)	Ammonia	Methyl Mercaptan (ppm)	Dimethyl Disulfide (ppm)	Butyraldehyde (ppm)
B1	Splitter Structure #2	High	Low	-	ND	ND	High
B2	HRTB Influent	High	Low	-	ND	ND	Low
B3	Grit Dumpster	High	Low	-	ND	ND	High
B4	Grit Tank Influent	-	-	-	-	-	-
1	DAFT Outlet	High	ND	ND	ND	Low	-
2A	East Headworks 1st Floor	High	Low	ND	Low	ND	-
2B	East Headworks 2nd Floor	High	Low	ND	ND	ND	-
3	West Headworks	High	Low	ND	Low	ND	-
4A	East Headworks Grit Channel	High	Low	ND	Low	Low	-
4B	West Headworks Grit Channel	High	Low	ND	Low	ND	-
5	Dumpster Room	High	Low	ND	Low	Low	-
9	Digester	High	Low	ND	Low	ND	-
10	Dewatering Building Exhaust	High	Low	Low	Low	Low	-
12	Silo Dust Scrubber Outlet	High	Low	Low	High	Low	-
13A	RTO # 1 Inlet	High	Low	Low	High	Low	-
13B	RTO # 2 Inlet	High	Low	Low	High	High	-
14A	RTO # 1 Outlet	High	Low	High	High	High	-
14B	RTO # 2 Outlet	High	Low	Low	High	High	-
17A	Fugitive Dust Scrubber # 1 Outlet	High	Low	High	High	High	-
17B	Fugitive Dust Scrubber # 2 Outlet	High	Low	Low	High	High	-
18	MEB Exhaust	High	Low	ND	Low	Low	-
U1	Aerated Influent Channel	High	High	-	Low	Low	-
U2	Sed. Basin #1 Inlet	High	Low	-	Low	High	-
U3	Sed. Basin #1 Outlet	High	Low	-	Low	ND	-
U4	Sed. Basin #1 Weir	High	Low	-	Low	ND	-
U5	Sed. Basin #4 Inlet	High	Low	-	Low	Low	-

U6	Sed. Basin #4 Outlet	High	6.55	-	0.14	ND	-
U7	Sed. Basin #4 Weir	High	56.0	-	0.35	ND	-
U8	Sed. Basin Eff. Channel	High	33.5	-	0.30	ND	-

*Red text indicates sampling location exceeded analyte target limit at the odor source.
**Target odor threshold is 20 D/T at the fence line and will be determined via air dispersion modelling. Odor values presented here are taken at the source, not at the fence line
H_2S= Hydrogen Sulfide
ppm= parts per million
ND= Non-Detect – Compound was analyzed for, but not detected above the method detection limit
D/T = Dilution to threshold

Table 3-5 Collection System 2021-2022 Sampling Results

	Liquid			Vapor		
ID	BOD_5 (mg/L)	TSS (mg/L)	Odor** (D/T)	H_2S (ppm)	Butyraldehyde (ppm)	Max Pressure (In H2O)
1	High	Low	High	Low	ND	High
2	-	-	High	ND	ND	-
3	Low	Low	High	Low	High	High
4	High	High	High	SL	Low	Low
5	Low	Low	High	Low	ND	High
6	High	Low	High	Low	Low	High
7	Low	Low	High	Low	ND	Low
8	-	-	High	Low	ND	-
11	High	Low	High	Low	High	Low
12	NL	NL	High	Low	ND	-
13	ND	Low	High	Low	ND	High
14	-	-	High	SL	ND	-

*Red text indicates sampling location exceeded analyte target limit at the odor source.
**Target odor threshold is 20 D/T in the service area and will be determined via air dispersion modelling. Odor values presented here are taken at the source.
H_2S= Hydrogen Sulfide
BOD= Biological Oxygen Demand
TSS= Total Suspended Solids
ppm= parts per million
ND= Non-Detect – Compound was analyzed for, but not detected above the method detection limit
- = Substance was not sampled for or has not been analyzed by the appropriate laboratory
D/T = Dilution to threshold
SL= Sample Loss – Air sample was damaged during shipment to laboratory

Table 3-6 Pump Station 2021-2022 Sampling Results

ID	Location	Odor** (D/T)	H_2S (ppm)	Dimethyl Disulfide (ppm)	Max Pressure (In H2O)
S1	Dumpster Room	High	Low	Low	-
S2	Splitter Structure #1	High	High	ND	-
S3	Influent Junction Structure	-	-	-	-
F1	Lower Level	High	Low	High	0.186
F2	Roof Exhaust	High	Low	Low	-

ST1	Lower Level	High	Low	Low	0.015
ST2	Roof Exhaust	High	Low	Low	-
G1	Carbon Inlet	High	Low	Low	0.005
G2	Carbon Outlet	High	Low	Low	0.427
N1	System Inlet 1	High	Low	Low	0.563
N2	System Outlet 1	High	Low	Low	-
N3	System Inlet 2	High	Low	ND	0.043
N4	System Outlet 2	High	Low	Low	-
ND1	Lower Level	High	Low	ND	0.655
U1	Wetwell Room	High	Low	ND	- 0.067
U2	Bar Screen Channel Exhaust	High	Low	ND	- 0.185

*Red text indicates sampling location exceeded analyte target limit at the odor source.
**Target odor threshold is 20 D/T in the service area and will be determined via air dispersion modelling. Odor values presented here are taken at the source.

H_2S= Hydrogen Sulfide
ppm= parts per million
ND= Non-Detect – Compound was analyzed for, but not detected above the method detection limit
D/T = Dilution to threshold

3.3 Sampling Conclusions

For the WWTF and MFWQTC, liquid sampling was performed at the WWTF #1 Grit Tank Influent only, and the results indicate no exceedances of analyte target limits. In the collection system, liquid sampling results indicated that there is a correlation between odorous compounds and high BOD. Lower pH readings (H_2S more likely to be present) appeared to coincide with high BOD measurements. For example, the Sample ID #11 BOD measurement was remarkably high and coincided with the lowest pH reading. However, dissolved oxygen was not low at this location when compared the other locations. Overall, these conditions are favorable for odor generation. Finally for the pump stations, liquid sampling results indicated moderate exceedances of analyte target limits at PS #5 and no exceedances at PS #8 and PS #6.

The vapor sampling results indicated exceedances of analyte target limits at several locations within the WWTF #1, MFWQTC, selected areas of the collection system, and selected pump stations. Pressure monitoring results in the collection system and pump stations indicated that most of the sampling locations operate at positive pressure which releases untreated air into the surrounding environment.

Table 3-7, Table 3-8, and Table 3-9 summarize the vapor and liquid sampling results evaluation, respectively, for each of the sampling locations. They were developed to aid the odor control master plan in the selection of odor control improvements and mitigation of current odor impacts within the treatment facilities.

Table 3-7 Morris Forman WQTC and WWTF #1 Sampling Conclusions Summary

Sampling Location	Target Limit Exceedance(s)**	Odor Control Priority
U7: Sed. Basin #4 Weir	Odor	High
U1: Aerated Influent Channel	Odor, H_2S	High
U2: Sed. Basin #1 Inlet	Odor, Dimethyl Disulfide	High

U8: Sed. Basin Eff. Channel	Odor	High
U3: Sed. Basin #1 Outlet	Odor	High
U5: Sed. Basin #4 Inlet	Odor	High
U4: Sed. Basin #1 Weir	Odor	High
17B: Fugitive Dust Scrubber # 2 Outlet	Odor, Methyl Mercaptan, Dimethyl Sulfide	High
U6: Sed. Basin #4 Outlet	Odor	High
17A: Fugitive Dust Scrubber # 1 Outlet	Odor, Ammonia, Methyl Mercaptan, Dimethyl Sulfide	High
4B: West Headworks Grit Channel	Odor	High
B1: WWTF #1 Splitter Structure #2	Odor, Butyraldehyde	High
1: DAFT Exhaust	Odor	High
4A: East Headworks Grit Channel	Odor	High
14A: RTO # 1 Outlet	Odor, Ammonia, Methyl Mercaptan, Dimethyl Sulfide	High
14B: RTO # 2 Outlet	Odor, Methyl Mercaptan, Dimethyl Sulfide	High-Low
10: Dewatering Building Exhaust	Odor	High-Low
3: West Headworks	Odor	High-Low
9: Digester	Odor	High-Low
12: Silo Dust Scrubber Outlet	Odor, Methyl Mercaptan	High-Low
2A: East Headworks 1st Floor	Odor	Low
5: Dumpster Room	Odor	Low
2B: East Headworks 2nd Floor	Odor	Low
18: MEB Exhaust	Odor	Low
B3: WWTF #1 Grit Dumpster	Odor, Butyraldehyde	Low
B2: WWTF #1 HRTB Influent	Odor	Low
13A: RTO #1 Inlet	Odor, Methyl Mercaptan	N/A*
13B: RTO #2 Inlet	Odor, Methyl Mercaptan, Dimethyl Sulfide	N/A*
B4: WWTF #1 Grit Tank Influent	-	N/A*

* The inlet odor parameters are less important than the odor outlet parameters.
** MSD is only required to meet the liquid discharge regulations and the APCD standard for gaseous H_2S concentrations at the source

Table 3-8 Collection System Sampling Conclusions Summary

Sampling Location	Location Description	Potential Odor Receptors	Target Limit Exceedance(s)*	Odor Control Priority
6	Ohio River Interceptor	Chickasaw residents, Adjacent properties near Plant	BOD, Odor, Pressure	High
4	Western Outfall	Chickasaw residents	BOD,TSS, Odor, Pressure	High
12	Western Outfall	Chickasaw residents	Odor	Moderate
5	Western Outfall	Chickasaw residents	Odor, Pressure	Moderate
11	Western Outfall	California residents	BOD, Odor, Butyraldehyde	Moderate
7	Southern Outfall	Park DuValle residents	Odor	Moderate
1	Northwestern Interceptor	Shawnee residents	BOD, Odor, Pressure	Low
3	Northwestern Interceptor	Shawnee residents	Odor, Butyraldehyde, Pressure	Low
8	Southern Outfall	Park DuValle residents	Odor	N/A
14	Southern Outfall	Park DuValle residents	Odor	N/A
2	Northwestern Interceptor	Shawnee residents	Odor	N/A
13	Western Outfall	California residents	Odor	N/A

* MSD is only required to meet the liquid discharge regulations and the APCD standard for gaseous H_2S concentrations at the source

Table 3-9 Pump Station Sampling Conclusions 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

* MSD is only required to meet the liquid discharge regulations and the APCD standard for gaseous H_2S concentrations at the source

4. Current Odor Control Technologies Evaluation

4.1 MFWQTC Odor Control Technologies

4.1.1 MFWQTC Current Odor Technologies Characterization

The MFWQTC is currently equipped with several odor control technologies for the treatment of air generated from various process areas. A summary of the existing odor control technologies is shown in Table 4-1 which includes the manufacturer, model, number of units, installation year, and associated odor sources. The existing conditions of each odor control system were evaluated and are discussed in this Section.

Table 4-1 Existing Odor Control Technologies Summary

	Odor Control System	Manufacturer/ Model	# of Units	Year Installed	Associated Odor Source(s)
1	BOC	Bioway Purspring 1000	(2)	2007	Aerated Influent Channel
2	SHOC	Biorem Biofiltair	(2)	2006; Rebuilt in 2011	MEB Dewatering Area (1), Sludge Holding Tanks
3	RTOs (2)	Gulf Coast Environmental Systems 100-95-RTO	(2)	2022	MEB Dewatering Area, MEB Sludge Drying Area (1)
4	MEB Acid Scrubbers (2)	Andritz TOP-85 DT-CB/SUMP-VT520’2 OT-DB-SS	(2)	2022	MEB Dewatering Area, MEB Sludge Drying Area (1)
5	MEB Fugitive Dust Wet Scrubbers (2)	Monroe Environmental DT-3000-SS	(2)	2022	MEB Sludge Drying Area Fugitive Dust
6	MEB Silo Dust Wet Scrubber (2)	Monroe Environmental DT-1000	(1)	2022	MEB Storage Silos Fugitive Dust

(1) – MEB Dewatering Area and MEB Sludge Drying Area process sludge from the Digesters.

(2) – The Emergency Dryer Replacement Project was recently completed with the installation of new RTOs, MEB Acid Scrubbers, MEB Fugitive Dust Wet Scrubbers, and MEB Silo Dust Wet Scrubber.

4.1.1.1 Biotower Odor Control (BOC)

The Plant’s existing BOC system was installed in 2007 to replace the original chemical scrubbers serving the Bioroughing towers. These units were originally designed to receive and treat air from the existing Bioroughing towers and the Aerated Influent Channel. The Bioroughing Towers were taken out of service in 2017; therefore, the BOC system currently treats foul air from the Aerated Influent Channel.

The BOC system consists of two (2) identical Purpring 1000 biotrickling scrubbers manufactured by Bioway. Each scrubber is equipped with a 30-ft diameter tower which contains synthetic media with biomass used for air treatment. The existing BOC units are pictured in Figure 4-1.

Figure 4-1 Existing BOC System Photo 2009

4.1.1.2 Solids Handling Odor Control (SHOC)

The SHOC system was installed in 2007 to replace the fume incinerators for treatment of foul air from the MEB and Sludge Receiving Tanks. One of the existing fume incinerators remained as a backup to the SHOC system until 2007 when it was decommissioned. The SHOC system treats air from the Sludge Holding Tanks and MEB sludge drying area including the centrifuge conveyors, wet material bins, and dewatering wet well. The Sludge Receiving Tanks are currently out of service and therefore no longer convey air streams to the SHOC.

The SHOC system consists of two (2) 14-ft diameter multi-stage biological odor control units. Each bioreactor consists of three (3) stages:

1. Stage 1 (Preliminary Treatment via Biotrickling) – Foul air is humidified, and H2S is degraded in acidic conditions.
2. Stage 2 (Biological Oxidation) – Air passes through two biofilter media beds where H2S is solubilized and bio-oxidized by microbes. MSD currently operates Stage 2 in Alpha mode (low pH) to primarily remove H2S.
3. Stage 3 (RSC Removal) – Biofilter media is used to remove residual H2S and other RSCs, resulting in additional TRS removal. An irrigation system was installed to clean the biotrickling filters and biofilters.

The SHOC system was rebuilt in 2011. After running Beta mode per previous odor control recommendations, the support columns of the scrubbers collapsed. After the re-build, MSD changed the media type in Stage 3 to improve reduced sulfur RSC removal. The existing SHOC system is pictured in Figure 4-2.

Figure 4-2 Existing SHOC System Photo, 2009

4.1.1.3 Regenerative Thermal Oxidizers (RTOs)

The existing RTO units are used to reduce VOCs in the air from the MEB dryer system and were recently replaced under the Emergency Dryer Replacement project. The MEB drying system operates under negative pressure which allows the collection and treatment of foul air through the RTOs. The RTO system consists of two (2) identical RTOs manufactured by Gulf Coast Environmental Systems. Each RTO has a dedicated exhaust fan, dryer train, and air duct.

4.1.1.4 MEB Main Process Wet Scrubbers

The MEB is currently equipped with two (2) venturi scrubbers designed to treat dust streams produced during the sludge dewatering and drying process. These scrubbers are housed on the 6th floor of the MEB.

4.1.1.5 MEB Acid Scrubbers

The MEB is currently equipped with two (2) acid scrubbers designed to remove ammonia immediately following the venturi scrubbers; however, these units are currently only operating as a pass-through.

4.1.1.6 MEB Fugitive Dust Wet Scrubbers

Two (2) Fugitive Dust Wet Scrubbers are in the MEB and treat fugitive dust from the solids recycling bins, crushers, screeners, and pellet coolers.

4.1.1.7 MEB Silo Dust Wet Scrubbers

One (1) Wet Scrubber is located in the MEB and treats fugitive dust from the MEB solids storage silos.

4.1.2 MFWQTC Design Parameters and Operation Performance Review

Equipment specifications and reports were evaluated to identify key design parameters for each of the existing or planned future odor control systems and is summarized Table 4-2. The project team also compiled previous performance testing results and expected performance parameters to assess the current operational performance. The results from previous sampling events and the most recent sampling in 2020, 2021, and 2022 at the Morris Forman WQTC were used to evaluate the systems performance in the subsequent sections.

Table 4-2 Existing Odor Control System Design Summary

Odor Control System	Inlet Conditions: Peak Capacity (cfm)	Inlet Conditions: Average/ Peak H_2S Conc. (ppmv)	Inlet Conditions: Average/ Peak Odor Conc. (D/T)	Expected Performance
BOC	20,000	60 / 150	N/A	99% H_2S Reduction or less than 0.1 ppmv outlet concentrations when inlet levels are less than 150 ppmv
SHOC	9,200	150 / 200	< 6,000 / 15,000	99% H_2S Reduction; 80% TRS Reduction
RTOs	10,000	0.359 (average)	1,024,922	95% Removal Efficiency or less than 10 ppmv outlet concentrations
MEB Acid Scrubbers #1	3,000	N/A[1]	N/A[1]	N/A
MEB Acid Scrubbers #2	3,000	N/A[1]	N/A[1]	N/A
MEB Fugitive Dust Wet Scrubbers #1[1]	6,000	N/A[1]	N/A[1]	95% Removal Efficiency
MEB Fugitive Dust Wet Scrubbers #2[1]	6,000	N/A[1]	N/A[1]	95% Removal Efficiency
MEB Silo Dust Wet Scrubber[1]	1,000	N/A[1]	N/A[1]	95% Removal of dust 2.0 microns or larger

[1]The data is not available because the inlet sampling was not possible.

N/A= Data not available from previous reports and manufacturer specifications.

4.1.2.1 BOC Performance Data Evaluation

MSD conducted performance testing at the BOC system in 2008. The study focused on H_2S and odor removal efficiency, and the performance data results are summarized in Table 4-3. The 2008 performance testing results showed that average H_2S removal efficiency was approximately 99% between the two BOC units which met the manufacturer expected performance. As part of the odor control master plan evaluation, odor reduction was also evaluated for impact on the overall MFWQTC system. The odor reduction was generally poor with an average odor reduction of 47%. However, the unit is not designed to have a specific target for odor removal. Outlet odor emissions were likely impacted by other non-sulfurous odor compounds, but amines, aldehydes, and VOCs were not sampled during the 2008 performance tests.

Table 4-3 BOC Performance Data Summary, 2008

Location	H2S Concentration % Reduction	Odor Concentration % Reduction
BOC Unit #1	99%	65%
BOC Unit #2	99%	28%
Average:	**99%**	**47%**

MSD is actively working towards the rehabilitation of the existing BOCs odor control system under the Rehabilitation and Replacement of Primary Sedimentation Basins Project. The proposed process airflow for the new system is estimated at 16,500 cfm.

4.1.2.2 SHOC Performance Data Evaluation

MSD has conducted several performance tests at the SHOC since the system was commissioned in 2006 and then rebuilt in 2011. The following sampling data was evaluated:

1. Phase 1 Sampling (original construction)
    a. Odor Sampling, July 2008
    b. Reduced Sulphur Compounds (RSC) and H_2S Sampling, September 2008
2. Phase 2 (After re-build)
    a. RSC and H_2S Sampling, November 2012
    b. RSC and H_2S Sampling, April 2013

A summary of the observed H_2S and TRS percent reductions versus the expected performance levels provided by the equipment manufacturer is shown in Table 4-4. This sampling data shows that both SHOC units exceeded the expected performance level of 99% H_2S reduction and 80% TRS reduction.

Table 4-4 SHOC Observed vs. Target H_2S and TRS % Reduction after Rebuild

	H_2S % Reduction		TRS % Reduction	
Location	Observed	Target	Observed	Target
SHOC Unit #1	99.9%	99%	91.1%-95.9%	80%
SHOC Unit #2	99.9%	99%	88.9%-95.9%	80%

*-Percent removal targets are based on manufacturer performance data for expected performance.

Based on the findings of previous performance data evaluation, the following conclusions were made regarding the existing SHOC system:

- SHOC Unit #2 has shown better operating performance than SHOC Unit #1 in terms of RSC removal.
- 99% H_2S reduction target was met during each performance test for both SHOC units.
- 80% TRS reduction target was met for all performance tests.

4.1.2.3 MEB Odor Control Performance Evaluation

The RTOs, MEB Acid Scrubbers, MEB Fugitive Dust Wet Scrubbers, and MEB Silo Dust Wet Scrubber were installed and commissioned as part of the Emergency Dryer Replacement Project for the MEB. Vapor sampling was conducted in Summer 2022 as a part of the Odor Control Master Plan at the following locations:

- RTO #1 Inlet
- RTO #1 Outlet
- RTO #2 Inlet
- RTO #2 Outlet
- Fugitive Dust Wet Scrubber #1 Outlet
- Fugitive Dust Wet Scrubber #2 Outlet
- Silo Dust Wet Scrubber Outlet
- MEB Exhaust

The results for key odor compounds in the RTOs are summarized in Table 4-5. Sampling data shows that both RTOs demonstrated significant odor reduction with RTO #1 reducing the odor D/T by 99% and RTO #2 by 98%. However, the outlet odor values were still high.

Interestingly, the measured concentrations of odor causing compounds appeared to increase after RTO treatment. As a result, methyl mercaptan and dimethyl disulfide concentrations were higher than their respective reference concentrations reported in TM#6A for both units. These workplace and environmental references were used to identify elevated concentrations of odorous compounds and were used as a reference for comparison only. RTO #1 also exceeded the concentration reference for ammonia. The percent reductions for these compounds were therefore reported as 0% since the concentrations increased from the inlet to the outlet.

RTO #1 and #2 had similar flow rates which differed by 200 cfm on average. RTO #1 generally performed better than RTO #2 for all measured parameters except for ammonia which was 10 times more concentrated in RTO #1 than in RTO #2. The large variance in ammonia concentrations suggests that additional performance evaluation for the RTOs may be required.

The following conclusions were made for the RTO system based on the recent sampling:

- RTO #1 performed better than RTO #2 for all measured parameters except for ammonia.
- Both RTOs showed an odor D/T reduction of at least 98%.
- Both RTOs had elevated methyl mercaptan and dimethyl disulfide concentrations, and RTO #1 also had an elevated ammonia concentration, when compared to guidance limits.
- Percent reductions of odor compounds were reported as 0% because their concentrations increased from the inlet to the outlet.

Table 4-5 RTO #1 and RTO #2 Preliminary % Reduction

	RTO #1 % Reduction (Avg)	RTO #2 % Reduction (Avg)
Flow Rate (cfm)	N/A	N/A
Odor (D/T)	99%	98%
Hydrogen Sulfide (ppmv)	0%	0%
Methyl Mercaptan (ppmv)	0%	0%
Dimethyl disulfide (ppmv)	0%	0%
Ammonia (ppmv)	0%	0%

See TM#6A for more information.
Target odor threshold is 20 D/T at the fence line. Odor values presented here are taken at the source.
The % reduction for hydrogen sulfide, methyl mercaptan, dimethyl disulfide, and ammonia is 0% to signify an increase in their concentrations from the inlet to the outlet of the RTOs.

Percent reductions of odor compounds were not able to be calculated for these sampling locations because inlet sampling was not possible.

Multiple odor compounds also exceeded their reference concentrations. Methyl mercaptan was elevated at the Silo Dust Wet Scrubber Outlet and Fugitive Dust Wet Scrubber Outlets. Dimethyl disulfide concentrations were elevated at both Fugitive Dust Wet Scrubber Outlets. Ammonia also exceeded its reference concentration at the Fugitive Dust Wet Scrubber Outlet #1 under average concentrations and at the Silo Dust Wet Scrubber Outlet under peak concentrations.

Performance between the Fugitive Dust Wet Scrubber Outlets was varied. Outlet #2 had a larger peak and average flow rate than Outlet #1. Outlet #2 had a larger odor D/T value and trimethylamine concentration, and outlet #1 had larger hydrogen sulfide, methyl mercaptan, dimethyl sulfide, dimethyl disulfide, and ammonia concentrations. The ammonia concentration in Outlet #1 was 10 times more concentrated than in Outlet #2.

The following conclusions were made for the Silo Dust Wet Scrubber, Fugitive Dust Wet Scrubber, and MEB Exhaust based on the preliminary sampling:

- Fugitive Dust Wet Scrubber Outlet #2 performed better than Outlet #1 for all measured parameters except for odor and trimethylamine.
- Methyl mercaptan concentrations were high at the Silo Dust Wet Scrubber Outlet and Fugitive Dust Wet Scrubber Outlets. Dimethyl disulfide concentrations were high at both Fugitive Dust Wet Scrubber Outlets. Ammonia was also elevated at the Fugitive Dust Wet Scrubber Outlet #1 under average concentrations and at the Silo Dust Wet Scrubber Outlet under peak concentrations.

4.1.3 MFWQTC Conclusions

Available performance data was compiled and evaluated for each existing odor control system at the WQTC. Table 4-6 summarizes available performance data from previous reports including average H_2S, odor, and TRS removal efficiency for each existing odor control system. A performance rating was included to indicate whether each performance efficiency target was met.

Table 4-6 Current Odor Technologies Performance Evaluation Summary

Odor Control System	Odor Conc. % Reduction	H_2S Conc. % Reduction	TRS Conc. % Reduction	Performance Rating(s)
(1) BOC	Unit 1: 65% Unit 2: 28%	Unit 1: 99.4% Unit 2: 99.5%	N/A	• Odor Removal: Poor • H_2S Removal: Meets target removal efficiency (99% reduction)
(2) SHOC	N/A	Unit 1: 99.8-99.9%[3] Unit 2: 99.8-99.9%[3]	Unit 1: 88.9-91.1%[3] Unit 2: 95.9%[3]	• H_2S Removal: Meets target removal efficiency (99% reduction) • TRS Removal: Meets target removal efficiency (80%)
(3) RTO	Unit 1: 99% Unit 2: 98%	Unit 1: 0%[1] Unit 2: 0%[1]	Unit 1: 0%[1] Unit 2: 0%[1]	• Odor Removal: Met target for Unit 1 but not for Unit 2 (95% reduction) • 10 ppmv max outlet concentration: Met target for all compounds except for ammonia in Unit 1
(4) Silo Dust Wet Scrubber	N/A[2]	N/A[2]	N/A[2]	• Elevated odor, methyl mercaptan, and ammonia (peak)

				concentrations .
(5) Fugitive Dust Wet Scrubber	N/A[2]	N/A[2]	N/A[2]	• Elevated odor, methyl mercaptan, and dimethyl disulfide concentrations for both units. Ammonia concentration high for Unit 1.

Performance data showed that the BOC and SHOC systems met manufacturer performance targets in terms of H_2S removal, but both systems had relatively high outlet odor concentrations measured at the source. The RTOs met the odor removal target in both Units. The 10 ppmv max outlet concentration was also met for all compounds except for ammonia in Unit 1. Percent removal could not be calculated for the Silo Dust Wet Scrubber, but average concentrations were elevated for odor, methyl mercaptan, and ammonia (peak). Percent removal could also not be calculated for the Fugitive Dust Wet Scrubber, but concentrations were elevated for odor, methyl mercaptan, and dimethyl disulfide for both units.

Based on the evaluation of current odor control technologies at MFWQTC, the following action items are proposed to improve the odor removal:

- Evaluate options for upgrading the current SHOC odor control technology, if determined necessary.
- Evaluate options for the BOC system under the Primary Sedimentation Basin Rehabilitation project.

4.1.4 MFWQTC Planned Process Modifications

As mentioned previously, MSD is in the process of performing several process modifications at the WQTC which will have significant impacts on existing odor emissions. The planned process modifications were previously documented in TM#4 and are discussed in this Section.

4.1.4.1 Sedimentation Basin Rehabilitation

MSD is in the process of performing the Rehabilitation and Replacement of Primary Sedimentation Basins project (Contract No. 16460). This project involves modifications to the existing Aerated Influent Channel, Primary Sedimentation Basins, North and South Pump Stations, installation of a Chemically Enhanced Primary Treatment (CEPT) system, and the addition of an odor control system at the Primary Sedimentation Basins and related equipment.

Two (2) conceptual odor control design alternatives were presented in a Basis of Design Report (BODR) to improve odor conditions at the Primary Sedimentation Basins and related areas:

- Alternative 1: Re-purpose the existing BOC system
- Alternative 2: Install a new odor control system involving new biotrickling scrubbers

Regardless of the selected alternative, MSD plans to perform the following improvements:

- Coverings at the Aerated Influent Channel
- Coverings at the Sedimentation basin Effluent Weirs

- Coverings at the Sedimentation Basin Effluent Channels
- Conveyance ductwork from capture locations to Odor Control System

Table 4-7 summarizes the preliminary basis of design parameters for the proposed odor control systems included in the BODR.

Table 4-7 Sedimentation Basin Odor Control System Basis of Design Summary

Parameter	Alternative 1	Alternative 2
Manufacturer:	Bioair or Evoqua	Bioway
Process Conditions:	Continuous	Continuous
Process Airflow:	16,500 cfm	20,000 cfm
Inlet H_2S Conditions:	30 ppmv (avg)/ 200 ppmv (peak)	60 ppmv (avg)/ 150 ppmv (peak)

Alternative 1 was the selected odor control strategy based on MSD's experience with the BOCs, anticipated odor compounds and concentrations, lower O&M requirements compared to other methods, and proven efficacy. The selected alternative is shown in Figure 4-3.

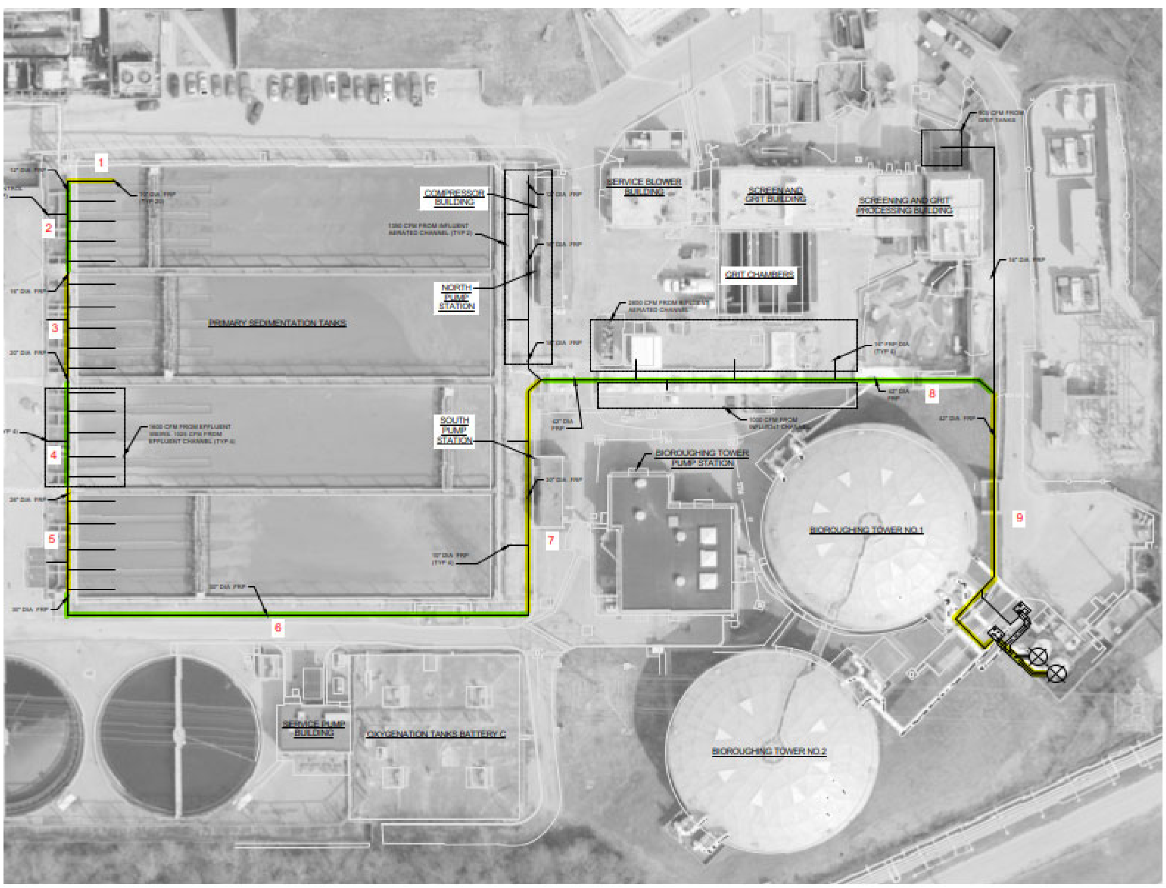

Figure 4-3 Sedimentation Basin Odor Control System Selected Alternative

4.2 Collection System Odor Control Technologies

4.2.1 Collection System Odor Technologies Characterization

4.2.1.1 Bioxide Injections

Beginning in April 2014, MSD contracted a third-party firm to perform routine chemical dosing and H_2S monitoring at target locations in the wastewater collection system, with the overarching goal of preventing corrosion of the ORFM. According to the July 2020 Invitation to Bid (ITB), a total of nine (9) chemical feed systems were installed within the Morris Forman service area. These feed systems are operated seasonally when H_2S is present with the system. In addition to chemical dosing, H_2S monitoring at locations downstream of the Bioxide injections was performed to evaluate the effectiveness of the injections on removing odorous compounds within the distribution system.

Most of the Bioxide feed and sampling locations are located outside of the Morris Forman service area and therefore are outside of the study area for this report. Within the study area, the majority of Bioxide feed and sampling sites are located towards the northeast, immediately upstream of the ORFM and the receiving ORI. Dosing rates for each Bioxide dosing site were provided to MSD quarterly – in March, May, July, and October of each calendar year.

4.2.1.2 ARV Biofilter

A biofilter pilot was installed at the an ARV as a part of the Ohio River Force Main Odor Study. The biofilter system consisted of two stages; the first stage involved a 4-ft by 8-ft precast tank with 3 feet of biofilter media (Bohn brand), and the second stage included a 4-ft by 8- ft precast tank with 3 feet of activated carbon media. This field test was initiated to evaluate the H_2S reduction efficiency of the proposed ARV biofilter system and its potential implementation across the ORFM.

4.2.1.3 Pump Station Oxygen System

Recent improvements were made to reduce odor emissions in the ORFM area which include the closing of the smaller diameter barrel on a portion of the ORFM and the installation of an oxygenation system at a PS in 2021.

4.2.2 Collection System Design Parameters and Operation Performance Review

4.2.2.1 Bioxide Performance Data Evaluation

Monitoring locations were selected to assess the efficiency of H_2S reduction with Bioxide. Each of these H_2S monitoring sites were related to the associated upstream chemical dosing site(s) based on flow path, and a summary of the H_2S monitoring results is presented for each monitoring location in Table 4-8. A 10 ppm maximum H_2S concentration, defined in the "Ohio River Force Main Odor Study" was used to highlight locations with elevated H_2S concentrations.

Table 4-8 MFWQTC Collection System H2S Sampling From 2018-2020

Location Number	H_2S Monitoring Period	Average H_2S Concentration (ppm)			
		2018	2019	2020	2018-2020
1	Oct 2019 – Current	N/A	Low	Low	Low
2	Jan 2018 – Current	Low	Low	Low	Low
3	June 2018 – Current	Low	High	Low	Low
4	Sept 2019 – Current	N/A	High	High	High

5	Sept 2019 – May 2020	N/A	Low	Low	Low

Average H_2S concentrations were elevated for the entire monitoring period at the Location #3 and Location #4 in 2019. Peak H_2S concentrations are shown in TM#7B and were reported at Location #4. H_2S monitoring was not performed during periods without Bioxide injection, so the H_2S removal efficiency of Bioxide was not easily observable. Nonetheless, average concentrations of H_2S suggested a low H_2S reduction efficiency at the Bioxide injection locations, particularly at the ORFM dosing location and PS #2.

4.2.2.2 ARV Biofilter Performance Data Evaluation

The biofilter system was monitored for inlet and outlet H_2S concentrations from August to October 2017 which is summarized in Table 4-9. On average the biofilter H_2S removal was considered acceptable with a minimum efficiency of 79.5% during the first monitoring phase and a maximum efficiency of 99.9% during the final monitoring phase. However, the biofilter performance was less efficient for peak inlet H_2S loadings, with peak H_2S removal efficiencies ranging from 63.6% to 95.5%. Based on the average H_2S removal efficiency results, the Consultant concluded that the biofilter system was an effective tool in this application and therefore included the ARV biofilter systems as part of the future ORFM odor control alternatives. However, peak H_2S outlet concentrations were extremely high, exceeding the 10 ppm threshold.

Table 4-9 Biofilter H2S Removal Efficiency, August-October 2017

H_2S Monitoring Period	Average H_2S Removal Efficiency (%)	Peak H_2S Removal Efficiency (%)
8/11-8/24	79.50%	91.40%
8/24-9/5	84.00%	63.60%
9/5-9/19	99.70%	95.50%
9/19-10/4	99.60%	76.50%
10/4-10/21	99.90%	94.50%

4.2.2.3 PS Oxygen System Performance Data Evaluation

MSD monitored H_2S levels at key areas along the ORFM before and after start-up of the PS oxygen feed to evaluate its performance. H_2S monitoring results indicate that H_2S levels were significantly reduced as a result of the oxygen system operation. It should also be noted that the oxygen system was down for an extended period of time (May 19 through June 11, 2021) which resulted in a spike in H_2S levels in downstream monitoring locations. These results suggest that recent improvements in the ORFM area have been able to reduce the H_2S levels. However other odor-causing compounds (RSCs, VOCs, etc.) were not monitored during this study, and the abundance of these chemical compounds is unknown.

4.2.3 Collection System Conclusions

Available data and reports were evaluated to understand the performance of existing odor control methods within the MFWQTC wastewater collection system and to identify target areas for further evaluation. Table 4-10 summarizes the status of the existing odor control technologies within the MFWQTC wastewater collection system.

Table 4-10 Current Odor Control Technologies Summary

Number	Odor Control System	Status
1	Bioxide injection	Inactive
2	Oxygen injection (Bioxide injection backup)	Active
3	Bioxide injection	Inactive
4	Bioxide injection	Active
5	Bioxide injection	Inactive
6	Bioxide injection	Active
7	Bioxide injection	Active
8	Bioxide injection	Inactive
9	Bioxide injection	Active
10	Biofilter	Active

Performance data for the Bioxide injections suggested a low H_2S reduction efficiency with both average and peak H_2S concentrations exceeding 10 ppm. On average the H_2S removal of the biofilter at the ARV was considered acceptable with a minimum efficiency of 79.5% during the first monitoring phase and a maximum efficiency of 99.9% during the final monitoring phase. However, the biofilter's H_2S removal was not sufficient under high H_2S loadings. Following the completion of the oxygen dosing system improvements at the PS, H_2S concentrations significantly decreased within the ORFM.

Based on the evaluation of current odor control technologies within the collection system, the following action items are proposed to improve odor removal:

- Evaluate options for piloting odor control technologies along the Grand Avenue Force Main
- Evaluate options for piloting new odor control units in the Western Outfall

4.3 Pump Stations Odor Control Technologies

4.3.1 Pump Stations Current Odor Technologies Characterization

Prior to the development of this report, a detailed review of existing documentation was performed in relation to odor control within the Morris Forman Pump Stations. Background documentation included previous studies, reports, and field sampling data to gain an understanding of MSD's odor control efforts to date and to investigate current odor conditions in specific areas of the pump stations. Key findings from the background documentation review process for the Morris Forman Pump Stations can be found in TM#3.

Of the seven (7) pump stations selected for evaluation and assessment, only three (3) are currently equipped with odor control technologies for the treatment of foul air generated from process areas. These three (3) were PS #5, PS #2, and PS #3. A summary of these pump stations' existing odor control technologies is shown in Table 4-11 including manufacturer and model, carbon media used, number of units, installation year and associated odor sources.

Table 4-11 Existing Odor Control Technologies Summary

Pump Station	Odor Control System	Manufacturer / Model	Carbon Media	# Of Units	Year Installed	Associated Odor Source(s)
PS #5	Dual-Bed Carbon Adsorber	N/A	Virgin Activated Carbon	(1)	2013	Influent Chamber, Screen Channels, Screen Room, Pipe Gallery, and Wet Wells
PS #2	Dual-Bed Carbon Adsorber	ECS RO10 Carbon Adsorber	High-Capacity Activated Carbon Virgin Coconut Shell Activated Carbon	(1)	2017	Wet Well, Screen Channels, Screen Room, Dumpster Area
PS #3	Dual-Bed Carbon Adsorber	ECS VX-7,600	Enhanced Virgin Coconut Shell Activated Carbon	(1)	2018	Wet Well, Inlet Channel, Screen Room, and Dumpster Area

Existing equipment specifications and reports were reviewed to identify key design parameters for each of the existing odor technologies and summarized in Table 4-12. The project team also compiled previous performance testing results and design performance parameters to assess the current operational performance.

Table 4-12 Existing Odor Control System Design Summary

Odor Control System	Inlet Conditions			Expected Performance
	Total Peak Capacity (cfm)	Average / Peak H_2S (ppmv)	Average / Peak Odor Conc. (ou)	
Dual-Bed Carbon Adsorber (PS #5)	10,000	1 - 10	N/A	1-10 ppm H_2S – 99% Removal Efficiency > 10ppm H_2S - 99% Removal Efficiency
Dual-Bed Carbon Adsorber (PS #2)	10,000	1 - 10	N/A	< 0.2 ppm H_2S in Outlet Air or 99% Removal Efficiency
Dual-Bed Carbon Adsorber (PS #3)	7,600	10	N/A	99.5% removal or less than 0.5 ppm in outlet air

4.3.2 Pump Station Design Parameters and Operation Performance Review

4.3.2.1 PS #5 Dual-Bed Carbon Adsorber Performance Data Evaluation

The existing dual-bed carbon adsorber in Pump Station #5, installed in 2013, provides odor control to the influent chamber, screen channels, screen room, pipe gallery, and wet wells of the pump station. The system treats foul air from the wet well via two 12” intakes. The Dumpster Room and Splitter Structure #1 are not tied to the existing odor control system. Table 4-13 summarizes the air sampling results pertaining to H_2S and odor pump station dumpster room and Splitter Structure #1.

Table 4-13 PS #5Odor Control System Performance Summary, 2021

Location	H_2S Concentration (ppm)	Odor Concentration (D/T)
	Room	Room
Dumpster Room	Low	High
Splitter Structure #1	High	High

H_2S and odor concentration removal efficiencies were not able to be calculated because air samples were taken within the process area and not from the inlet/outlet of the carbon adsorber. It is noted however that the pump station is currently in the design phase of a new odor control system that is designated to treat air from Splitter Structure #1.

Based on the findings of current performance data evaluations, the following conclusions were made regarding the existing odor control system:

- H_2S percent reduction was not able to be determined for the dual-bed carbon adsorber system since the locations that were sampled were not tied to the current odor control system.
- Odor concentrations have been noticed to be high in the splitter structure #1 area sampled. If splitter structure #1 is entered by personnel, air should be ventilated, treated, and monitored for safety purposes, limit environmental emissions, and prevent equipment corrosion. However, this area is not typically entered by maintenance personnel, so the risk of exposure is limited.

4.3.2.2 PS #2 Dual-Bed Carbon Adsorber Performance Data Evaluation

A third-party consultant conducted an air sampling program during Summer 2022 in the existing Pump Station #2 odor control room. The odor control system consists of one (1) 10,000 cubic feet per minute (cfm) carbon adsorber in a roll-off bin area. Odor emissions are conveyed through a 30-inch duct and pass through a grease filter before entering the carbon adsorber for treatment. The treated air is conveyed through a 24-inch fiberglass reinforced pipe (FRP) stack before being released into the atmosphere.

Table 4-14 summarizes the results of the 2022 air sampling period for the pump station odor control systems, including H_2S and odor concentrations and associated percentage (%) reduction.

Table 4-14 PS #2 Odor Control System Performance Summary, 2022

Location	H_2S Concentration % Reduction	Odor Concentration % Reduction
Carbon Inlet/Outlet	45.7%	50%

Available sampling data shows that the existing carbon adsorber met performance standards for H_2S removal with an H_2S percent reduction of 45.7%. This reduction percentage does not influence the current performance rating of the odor control system due to the inlet low concentration of H_2S (< 0.2 ppm) at the time of sampling. However, the performance should be further monitored to confirm its impact to the surrounding environment. The carbon adsorber was also analyzed for odor. The sampling results showed the carbon outlet had a 50% odor removal efficiency.

Based on the current performance data evaluations, the following conclusions were made regarding the existing odor control system:

- The H_2S reduction target of less than 0.2 ppm in the outlet air was met during the Summer 2022 sampling tests and is indicative of the carbon adsorber system meeting performance expectations.
- The odor reduction was only 50% which may result in odor complaints from the receptors in the proximity of the PS.

4.3.2.3 PS #3 Dual-Bed Carbon Adsorber Performance Data Evaluation

The third-party consultant conducted an air sampling program during Summer 2022 at the existing PS #3 odor control system which was installed in 2013 and updated in 2018.

Table 4-15 summarizes the results of the 2022 sampling period of the pump station odor control systems, including H_2S and odor concentrations and associated percent reduction.

Table 4-15 PS #3 Odor Control System Performance Summary, 2022

Location	H_2S Concentration % Reduction	Odor Concentration % Reduction
System 1	95.6%	25.6%
System 2	97.8%	70.2%

Available sampling data shows that the existing carbon adsorber is meeting performance standards for H_2S removal. Based on these results, the carbon adsorber met the H_2S reduction performance levels during the Summer 2022 sampling period.

The percent reduction of the odor control system for System 1 and System 2 were 95.6% and 97.8%, respectively. These percentages do not influence the current performance rating of the odor control system due to the low concentration of H_2S (< 0.5 ppm) at the time of sampling but are indicative of moderate performance which should be monitored further.

The odor control system was also analyzed for outlet odor concentration (D/T) and demonstrated a 25.6% and 70.2% odor concentration removal efficiency, respectively.

Based on the findings of current performance data evaluations, the following conclusions were made regarding the existing odor control system:

- The H_2S reduction target of less than 0.5 ppm in the outlet air was met during the Summer 2022 sampling tests and is indicative of the carbon adsorber system meeting performance expectations.
- The odor reduction was 25.6% for System 1 and 70.2% for System 2 which may result in odor complaints from the receptors in the proximity of the PS.

4.3.3 Pump Station Conclusions

Available performance data was compiled and evaluated for each selected pump station with an existing odor control system.

Table 4-16 summarizes the performance data including average H_2S and odor removal efficiency for each existing odor control system. A performance rating was included to indicate whether each performance efficiency target was met.

Table 4-16 Current Odor Technologies Performance Evaluation Summary

Locations	Odor Control System	Average Odor Conc. % Reduction	Average H_2S Conc. % Reduction	Performance Rating(s)
PS #5	Dual-Bed Carbon Adsorber	N/A	N/A	• Odor Removal: N/A, but high conc. within sampled area • H_2S Removal: N/A, but high conc. within sampled area
PS #2	Dual-Bed Carbon Adsorber	Carbon Outlet: 50%	Carbon Outlet: 45.7%	• Odor Removal: Moderate • H_2S Removal: Moderate
PS #3	Dual-Bed Carbon Adsorber	System 1: 25.6% System 2: 70.2%	System 1: 95.6% System 2: 97.8%	• Odor Removal: Moderate • H_2S Removal: Good

Available performance data showed that PS #2 and PS #3 odor control systems are meeting performance targets in terms of H_2S removal and had adequate removal of outlet odor concentrations. PS #2, based on H_2S percent reduction, should continue to be monitored for performance evaluation. PS #5 odor control system was unable to be evaluated as sampling locations were not tied to the existing control system.

PS #5 is set to have new odor control system installed specifically for Splitter Structure #1. Since the odor control system is already planned to be replaced, no new recommendations will be made for this facility. The new odor control system should undergo a performance test once installed to confirm the performance meets the intended design parameters.

Based on the evaluation of current odor control technologies both PS #3 and PS #2 will be considered for odor control improvements.

5. Odor Control Technologies Review

Feasible odor control technologies were identified and evaluated for odor removal efficiency, applicability, advantages, and disadvantages. Factors such as land footprint and relative cost considerations were also considered for each technology. Table 5-1 identifies the various odor control measures which were considered for inclusion into this Odor Control Master Plan. Multi-stage treatment configurations were also considered which involve staging of two or more technologies described herein. A description of the technologies considered as part of this master plan can be found in TM #8A, TM #8B, and TM #8C.

Table 5-1 Odor Treatment Technology Summary

Odor Control Technology		Description	Configuration(s)
Liquid Treatment Technologies			
1	Chemical Addition	Addition of odor control chemicals directly into wastewater stream	Bioxide (calcium nitrate), hydrogen peroxide, potassium permanganate, sodium hypochlorite, ferrous chloride, magnesium hydroxide
2	Oxygen Injection	Addition of oxygen into wastewater stream	Aeration systems or liquid oxygen injection
Vapor Treatment Technologies			
1	Adsorption	Attachment of odorous compounds to surfaces	Dry media scrubbers, fixed bed reactors, or adsorber wheel; Can be combined with thermal gas treatment or biofiltration
2	Absorption	Oxidation and dissolution of odorous compounds	Jet and venturi scrubbers, plate columns, and spray scrubbers
3	Biological Waste Gas Treatment	Degradation of odorous compounds via microorganisms	Biofilters, bioscrubbers, and biotrickling filters
4	Photoionization (UV)	Use of ultraviolet (UV) light and catalyst to oxidize odorous compounds	Ionization chambers
5	Hydroxyl Generator	Use of UV and optics to oxidize odorous compounds via hydroxyl molecules	Positive pressure systems involving process fans
6	Hydroxyl Advanced Oxidation	Use of ozone, water and air to oxidize odorous compounds via hydroxyl molecules	Positive pressure systems involving process fans

7	Ozonation	Generation of ozone (O3) for oxidation of odorous compounds	Single source or multiple source ozone generators
8	Portable Odor Control System	Maintain negative differential pressure in the trunk headspace compared to the ambient environment	Trailer mounted pilot unit including an activated carbon unit and a fan.

5.1 Technologies Comparison Summary

Table 5-2 outlines the advantages and disadvantages of each potential odor control technology considered as part of this Odor Control Master Plan.

Table 5-2 Odor Control Technologies Evaluation

Technology	Advantages	Disadvantages
Liquid Phase Technologies		
Chemical Injection	• Moderate capital costs • High removal of H_2S and dissolved sulfides • Minimal space required	• Chemical handling safety and environmental concerns • Reduced efficiency during peak loading • High long-term operation costs • Focuses on H_2S reduction and ignores contributions of other contaminants
Oxygen Injection	• High removal efficiency for odor, H_2S and RSC • No hazardous chemicals required • Smaller footprint	• May require high oxygen usage • Oxygen dosage requirements may be difficult to determine • Delivery and storage requirements
Vapor Phase Technologies		
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 • 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
Absorption	• High efficiency for RSC and odor removal • Rapid treatment • Potential for water recycling • Disinfectant (bacteria and viruses) • Increases biodegradability of product	• Chemical inputs required • Production, transportation and management of oxidants required • Efficiency is dependent by type of oxidant • Potential formation of intermediates including chlorine and amines • Potential sludge production
Biofiltration	• Low capital costs • Efficiently eliminates biodegradable organic matter • High removal of BOD and suspended solids	• Requires maintenance of optimal conditions for organisms • Slow process adaptation for intermittent operation • Potential sludge production and uncontrolled degradation products • High H_2S peak loadings may cause biofilter to acidify • High capital costs
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 for recirculation system

Photoionization (UV)	• High efficiency for odor, H_2S and RSC removal • Minimal impacts from high inlet air humidity • Minimal space requirements	• Relatively new technology for odor control application • Safety and environmental concerns due to possibility of unreacted radicals remaining in air stream • High energy demand requirements • High maintenance requirements
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, H_2S 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
Ozonation	• High efficiency for H_2S and RSC removal and corrosion prevention • Simplicity of treatment design	• Relative new technology for odor control application • Safety and environmental concerns due to possibility of unreacted ozone remaining in air stream • Performance limited by inlet air humidity • Extensive space requirements for contact chamber
Pilot Odor Control Alternatives		
Portable Odor Control System	• Can be setup in a short amount of time • Simplicity of treatment design • Highly effective in mitigating odor issues for a defined area.	• Depending on where the access manhole is located, may cause temporary road closures to perform the pilot • Not a permanent solution
Temporary Chemical Injection	• Allows quick testing of alternative chemicals to determine effectiveness • High removal of H_2S and dissolved sulfides • Minimal space required	• Chemical handling safety and environmental concerns • High long-term operation costs • Focuses on H_2S reduction and ignores contributions of other contaminants

6. Dispersion Modeling

As part of the Odor Control Master Plan, potential emissions of odor compounds were evaluated for the MFWQTC location and Pump Station #4 using an air dispersion modeling approach. The modeling was performed using emissions data from a variety of potential odor sources and was based on a 10-min averaging period (which was approximated from a 1-hour average modeled concentration). The odor modeling results were compared to a 20 OU/m^3 threshold on both a magnitude and frequency of exceedance threshold basis.

6.1 MFWQTC Modeling

6.1.1 Modeling Methodology

The American Meteorological Society/U.S. EPA has established AERMOD to be the preferred/ recommended dispersion model for neutral and buoyant plumes simple and complex terrain for receptors within 50 kilometers (31 miles) of a modeled source. AERMOD can handle the source geometry, terrain, and dispersion environment associated with this Project and, as such, was selected for use in this study. The analysis also accounted for building wake effects for various wind directions.

The latest version of AERMOD (version 22112)[1] was used to assess odor concentrations associated with MFWQTC at ground-level receptor locations within five kilometers (3.1 miles) of the facility. The modeling was performed using default model options in a rural dispersion environment with a densely spaced receptor grid and five years of meteorological data as described in the following sections.

6.1.2 Rural/Urban Dispersion Environment

One factor affecting input parameters to dispersion models is the assessment of the model application and the meteorological site's land use as either rural or urban. EPA's Appendix W guidance[2] (Appendix W) suggests that application of a model's dispersion environment as either rural or urban should be based upon the land use characteristics within 3 km (1.86 miles) of the project site(s) (EPA Appendix W to 40 CFR Part 51). Factors that affect the rural/urban choice include the extent of vegetated surface area, the water surface area, types of industry and commerce, density of residential areas, and building types and heights within this area.

According to Section 7.2.1.1 Appendix W, either a land use (Auer method) or a population density procedure should be used in determining if the model should be applied if there is an urban vs. rural dispersion environment. For this application, the Auer method is used. This land-use approach classifies an area according to 12 land-use types. In this scheme, areas of industrial, commercial, and compact residential land use are designated urban. According to Appendix W guidelines, if more than 50 percent of an area within a 3-km/1.86-mile radius of a site is classified as rural, the AERMOD's urban source options would not be used. Based on visual inspection of aerial imagery (see Figure 6-1), land cover within 3 km (1.86 miles) of the proposed project site is more than 50 percent rural land type. Therefore, the proposed project is considered rural and AERMOD was run in default model without any consideration of any urban source options for all sources modeled.

[1] User's Guide for the AMS/EPA Regulatory Model (AERMOD). EPA-454/B-22-007 (June 2022). Office of Air Quality Planning and Standards, Research Triangle Park, NC.
[2] US EPA 2017. Guideline on Air Quality Models (Revised). Codified in the Appendix W to 40 CFR Part 51. Office of Air Quality Planning and Standards, Research Triangle Park, NC. January 2017.

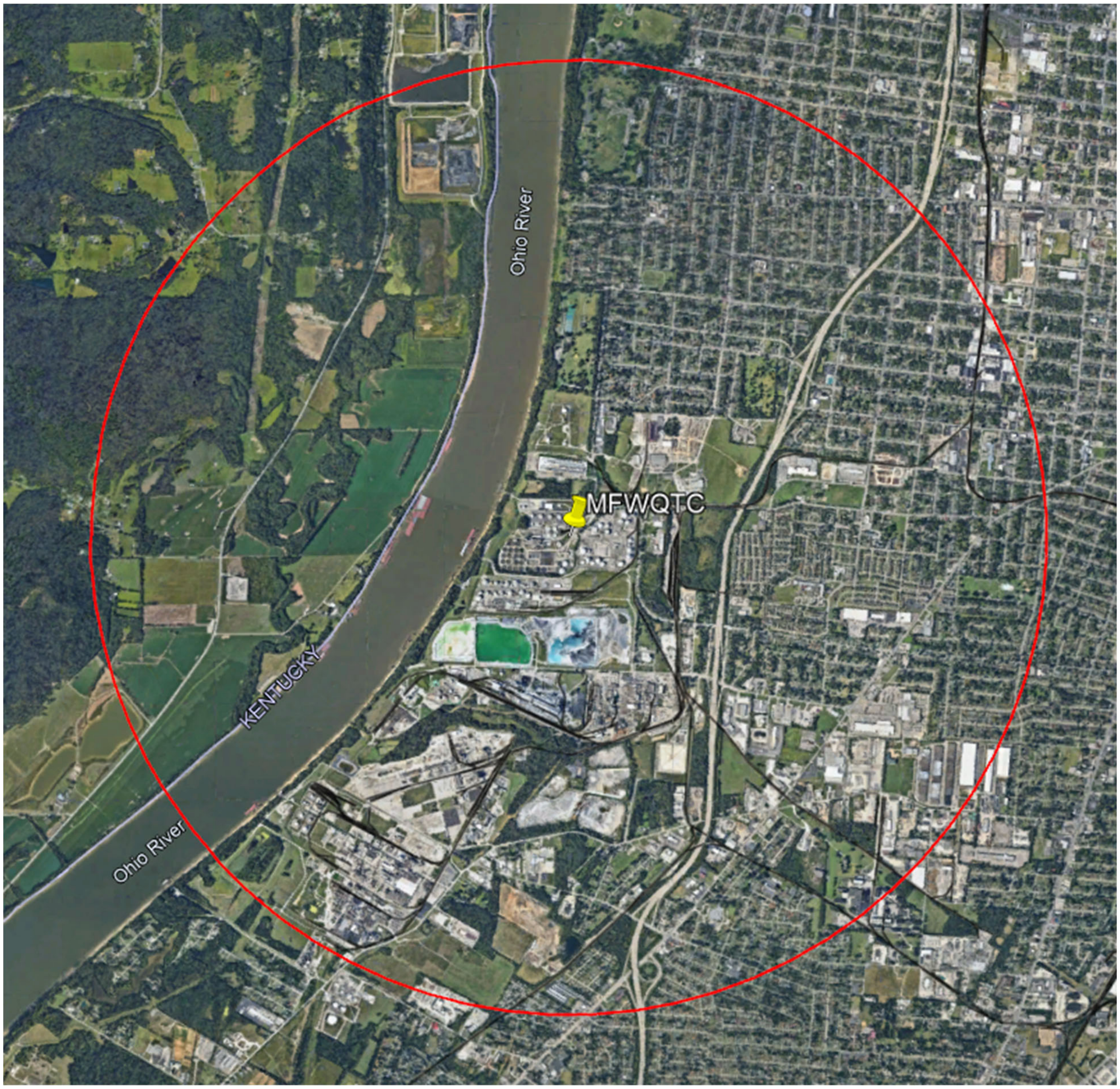

Figure 6-1 - Aerial Map of 3-km/1.86 mile Radius around MFWQTC

6.1.3 Meteorological Data

Hourly meteorological data used for air quality dispersion modeling must be spatially and climatologically representative of the area of interest and should be both laterally and vertically representative of the plume transport and dispersion conditions. Kentucky's Division for Air Quality (KDAQ) provides five years of surface and upper air meteorological data organized by region. The meteorological data used for this analysis (as recommended by KDAQ) included surface air data from Louisville-Standiford Field and Upper Air Data from Wilmington, Ohio and included the years 2017 through 2021. Louisville-Standiford Field is located approximately 11 km (7 miles) to the southeast of the facility.

6.1.4 Building Downwash

The latest version of the EPA Building Profile Input Program (BPIP-PRIME) was run to determine dominant structures for building downwash in AERMOD for the point sources that have the capability of emitting odorous compounds. These point sources include the odor control system (SHOCs, RTOs, BOCs, and wet scrubbers), Flare, and DAFT. For these sources, direction-specific building heights and widths of the dominant downwash structure(s) were included in the AERMOD model and input file directly from BPIP-PRIME output. These sources represent just the point sources of potential odor. Additional fugitive sources of odor are described in the following sections. The locations of these sources are shown in Figure 6-2 with respect to specific buildings included in the BPIP-PRIME modeling.

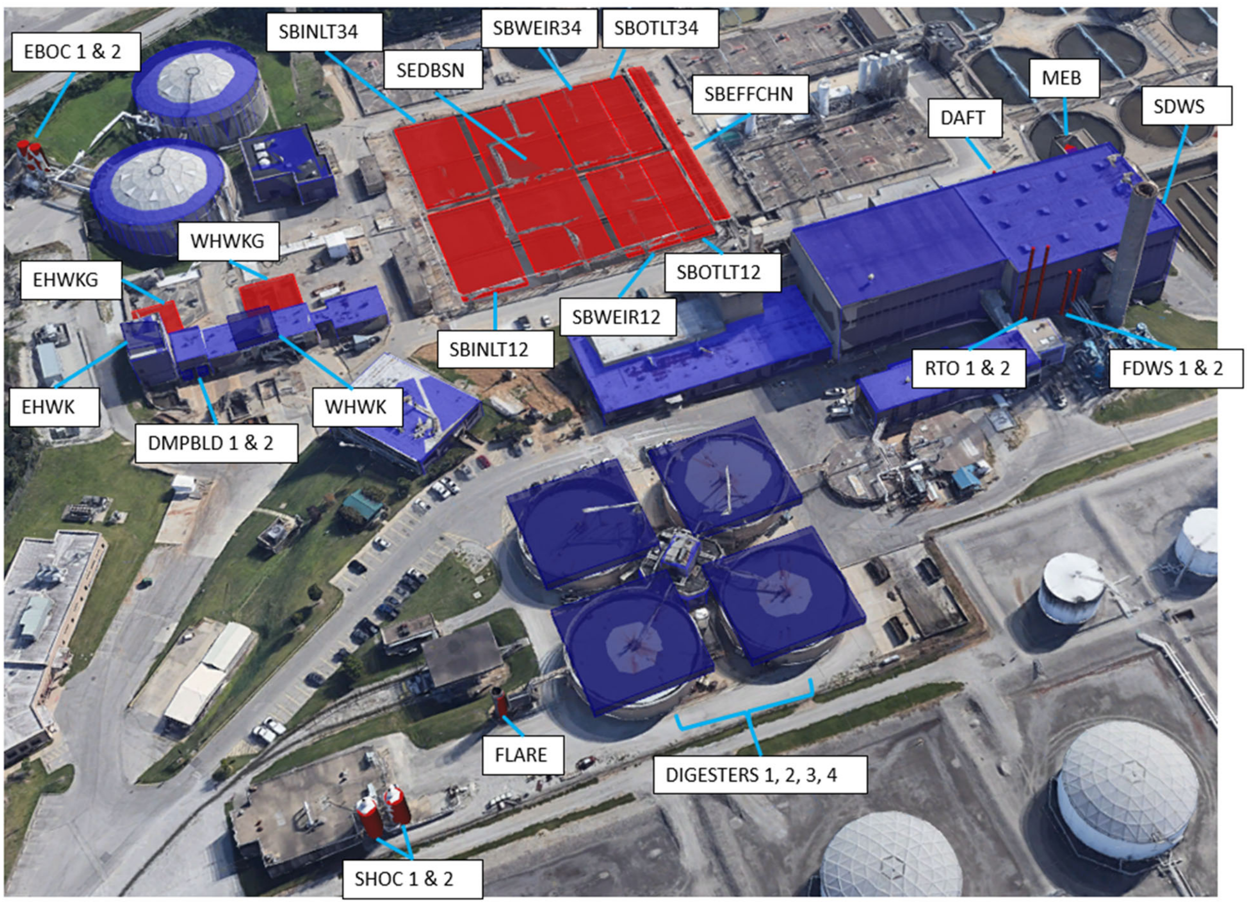

Figure 6-2 – Buildings and Sources included in BPIP-PRIME modeling

6.1.5 Receptor Locations and Terrain Processing

A comprehensive Cartesian receptor grid was developed for use in the AERMOD modeling. The grid was centered at the approximate center of the facility and extends out five kilometers (3.1 miles) from that location. The receptors were spaced at the following intervals in order to capture the maximum modeled concentrations in the portion of the receptor grid with the highest resolution:

- 50-m increment along the facility boundary;
- 100-m increment from facility boundary out to approximately 2500 meters; and

- 250-m increment from approximately 2,500 to 5,000 meters.

All receptor coordinates were in North American Datum 83 (NAD83), UTM Zone 16. A total of 3,889 receptors were used in the analysis, as shown in Figure 6-3.

Terrain elevations for the model receptors were obtained from readily available digital terrain elevations developed by the U.S. Geological Survey using its National Elevation Dataset (NED). The NED data provide terrain elevations with 1-meter vertical resolution and 10-meter (1/3 arc-second) horizontal resolution based on a Universal Transverse Mercator (UTM) coordinate system. For each receptor location, the terrain elevation is set to the elevation for the closest National Elevation Dataset grid point. The USGS specifies coordinates in NAD83, UTM Zone 16. EPA's AERMAP terrain processor (version 18081) was used to process the NED data and assign elevations to the receptor locations and sources.

Figure 6-3 - Location of AERMOD Modeled Receptors around MFWQTC

6.1.6 Source Data and Modeling Inputs

The odorous sources at MFWQTC include point sources and fugitive volume and area sources as described in Table 6-1 and Table 6-2. Emission calculations were based on odor concentration measurements obtained using sensors at locations referenced throughout the plan. These measurements are based on sample programs summarized in TM#6A.

Emission rates used in the AERMOD model were based on the odor concentration measurements and flow rate estimates for the source. In order for the model to provide output in OU/m^3, the corresponding modeled emission rate must be in the form of megaOU/s. As such, the following formula was used to calculate modeled emissions:

20,000 OU/m^3	x	14.6 m^3/sec	→	292,607 OU/sec	→	73,152 OU/sec	→	7.3152E-02 “mega”OU/sec	→	1.0461E-01 “mega”OU/sec
Exhaust gas conc. assuming 95% removal		31,000 ft^3/m design flow		Total system emissions		Emissions from each of 4 stacks		Convert to “mega” units so that AERMOD will output OU/m^3. Without conversion AERMOD would output “micro” OU/m^3		Multiply emissions by 1.43 to convert 1-hr emissions to “10-min” emissions

This is provided as an illustrative example calculation for an odor source that was divided evenly among 4 stacks.

The final piece of the example calculation is used to approximate a 10-minute average emission rate. Odor is an instantaneous nuisance and could be perceptible at averaging times on the order of a few seconds. Typical dispersion models (as used in this study) only estimate concentrations down to 1-hour averaging times. A power law function[3] was therefore applied to the hourly emission rates to estimate sub-hourly rates based on the following formula:

$$C_t = C_{60}\left[\frac{60}{t}\right]^{0.2}$$

t=time in minutes

All sources were assumed to be in operation continuously when assessing odor concentration. Figure 6-4 shows the point, area, and volume source locations for the odor modeling.

Three of the point sources, SHOC1, SHOC2, and the Flare, were not associated with an odor sensor. Instead, H_2S concentrations were used to approximate odor, using the following conversion[4]:

*Log (detection threshold) = 0.43 * Log (H_2S Conc.) + 3.28*

[3] Turner, D., 1969. Workbook of Atmospheric Dispersion Estimates. Office of Air Programs Publication No. AP-26.
[4] McGinley, M.A., C.M. McGinley, (2008). Odor Threshold Emission Factors for Common WWTP Processes. Water Environment Federation / Air & Waste Management Association Specialty Conference: Odors and Air Emissions 2008 Phoenix, AZ: 6-9 April 2008.

Table 6-1 - Proposed Emissions and Stack Parameters for Dispersion Modeling – Point Sources at MFWQTC

EMISSION DESCRIPTION	SOURCE ID	CORRESPONDING SENSOR NUMBER Used for D/T Emissions(1)	STACK HEIGHT (ft)	STACK TEMPERATURE (F)	FLOW RATE (ACFM)(2)	STACK DIAMETER (ft)	ODOR CONCENTRATIONS (D/T - dilution to threshold)	Emission Rate 10-MIN "mega"OU/sec
SHOC (BIOREM) 1	SHOC1	7A(3)	35.0	110.00	4,600	14.00	3,807	1.1826E-02
SHOC (BIOREM) 2	SHOC2	7B(3)	35.0	110.00	4,600	14.00	3,807	1.1826E-02
Regenerative Thermal Oxidizer 1	RTO1	14A	98.0	270.00	13,624	1.83	1,867	1.7178E-02
Regenerative Thermal Oxidizer 2	RTO2	14B	98.0	293.00	12,093	1.83	3,433	2.8037E-02
Fugitive Dust Wet Scrubber 1	FDWS1	17A	98.6	109.00	1,816	1.00	23,100	2.8330E-02
Fugitive Dust Wet Scrubber 2	FDWS2	17B	98.6	109.00	2,571	1.00	37,333	6.4821E-02
Silo Dust Wet Scrubber	SDWS	12	98.0	98.00	830	0.92	877	4.9159E-04
Existing BOCs (BIOWAY) 1	EBOC1	U3(4)	37.5	82.00	10,000	11.75	6,200	4.1871E-02
Existing BOCs (BIOWAY) 2	EBOC2	U3(4)	37.5	82.00	10,000	11.75	6,200	4.1871E-02
Flare	FLARE	None(3)	30.0	500.00	73,338	8.85	1,861	9.2152E-02
DAFT Outlet stack	DAFT	1	70.0	Ambient	39,400	2.00	3,800	1.0111E-01
Main Equipment Building Exhaust	MEB	18	80.0	Ambient	374,000	21.85	950	2.3995E-01

(1) Sensor location used for D/T measurement referenced throughout the plan.
(2) Flow rates are estimated based on building fan flow rates.
(3) Odor emission rate is based on H_2S from recent permit application.
(4) 2008 sensor data may not reflect current BOC conditions which are expected to decrease odor emissions.

Table 6-2 - Proposed Emissions and Parameters for Dispersion Modeling – Fugitive Sources at MFWQTC

EMISSION DESCRIPTION	SOURCE ID	CORRESPONDING SENSOR NUMBER Used for D/T Emissions[1]	RELEASE HEIGHT (ft)	FLOW RATE (ACFM)	SIDE LENGTH (m)	SIGMA Y (m)	ODOR CONCENTRATIONS (D/T)	Emission Rate 10-MIN “mega”OU/sec
Digester 1	DIG1	9	20.00	3.1[2]	29.44	6.85	1,117	2.3324E-06
Digester 2	DIG2	9	20.00	3.1[2]	29.44	6.85	1,117	2.3324E-06
Digester 3	DIG3	9	20.00	3.1[2]	29.44	6.85	1,117	2.3324E-06
Digester 4	DIG4	9	20.00	3.1[2]	29.44	6.85	1,117	2.3324E-06
East Headworks	EHWK	2A	30.00	10,000[3]	9.17	2.13	817	5.5175E-03
West Headworks	WHWK	3	20.00	10,000[3]	11.94	2.78	1,197	8.0838E-03
Dumpster Building Door 1	DMPBLD1	5	8.00	2,025.0[3]	2.44	0.57	1,300	1.7778E-03
Dumpster Building Door 2	DMPBLD2	5	8.00	2,025.0[3]	2.44	0.57	1,300	1.7778E-03

EMISSION DESCRIPTION	SOURCE ID	CORRESPONDING SENSOR NUMBER Used for D/T Emissions[1]	RELEASE HEIGHT (ft)	FLOW RATE (ACFM)	AREA (m^2)	ODOR CONCENTRATIONS (D/T)	Emission Rate 10-MIN “mega”OU/sec/m2
East Headworks Grit	EHWKG	4A	3.29	222.79[4]	164	3,733	3.4247E-06
West Headworks Grit	WHWKG	4B	3.29	353.20[4]	260	7,433	6.8192E-06
Sed. Basin #1 Inlet	SBINLT12	N/A[5]	3.29	1,086.76[4]	800	210,000	1.9266E-04
Sed. Basin #4 Inlet	SBINLT34	N/A[5]	3.29	1,086.76[4]	800	87,500	8.0274E-05
Sed. Basin #1 Outlet	SBOTLT12	N/A[5]	3.29	543.39[4]	400	96,000	8.8073E-05
Sed. Basin #4 Outlet	SBOTLT34	N/A[5]	3.29	543.39[4]	400	25,950	2.3807E-05
Sed. Basin #1 Weir	SBWEIR12	N/A[5]	3.29	923.75[4]	680	53,000	4.8623E-05
Sed. Basin #4 Weir	SBWEIR34	N/A[5]	3.29	923.75[4]	680	415,000	3.8073E-04
Sed. Basin Eff. Channel	SBEFFCHN	N/A[5]	3.29	543.39[4]	400	176,000	1.6147E-04
Sed. Basin	SEDBSN	N/A[5]	3.29	2,716.91[4]	2,000	104,863	9.6203E-05

(1) Sensor location used for D/T measurement referenced throughout the plan
(2) Flow rate is based a 5 mm tank gap, with total gap area of 2.58 ft^2 and a minimal exit velocity of 1.2 ft/min.
(3) Flow rate is estimated based on building fan flow rate.
(4) Flow rate is estimated based on an airflow of 5L/min per .13m^2 over the sampled area.
(5) Odor concentration is from St. Croix Sensory, Inc.’s October 2020 Odor Evaluation Report.

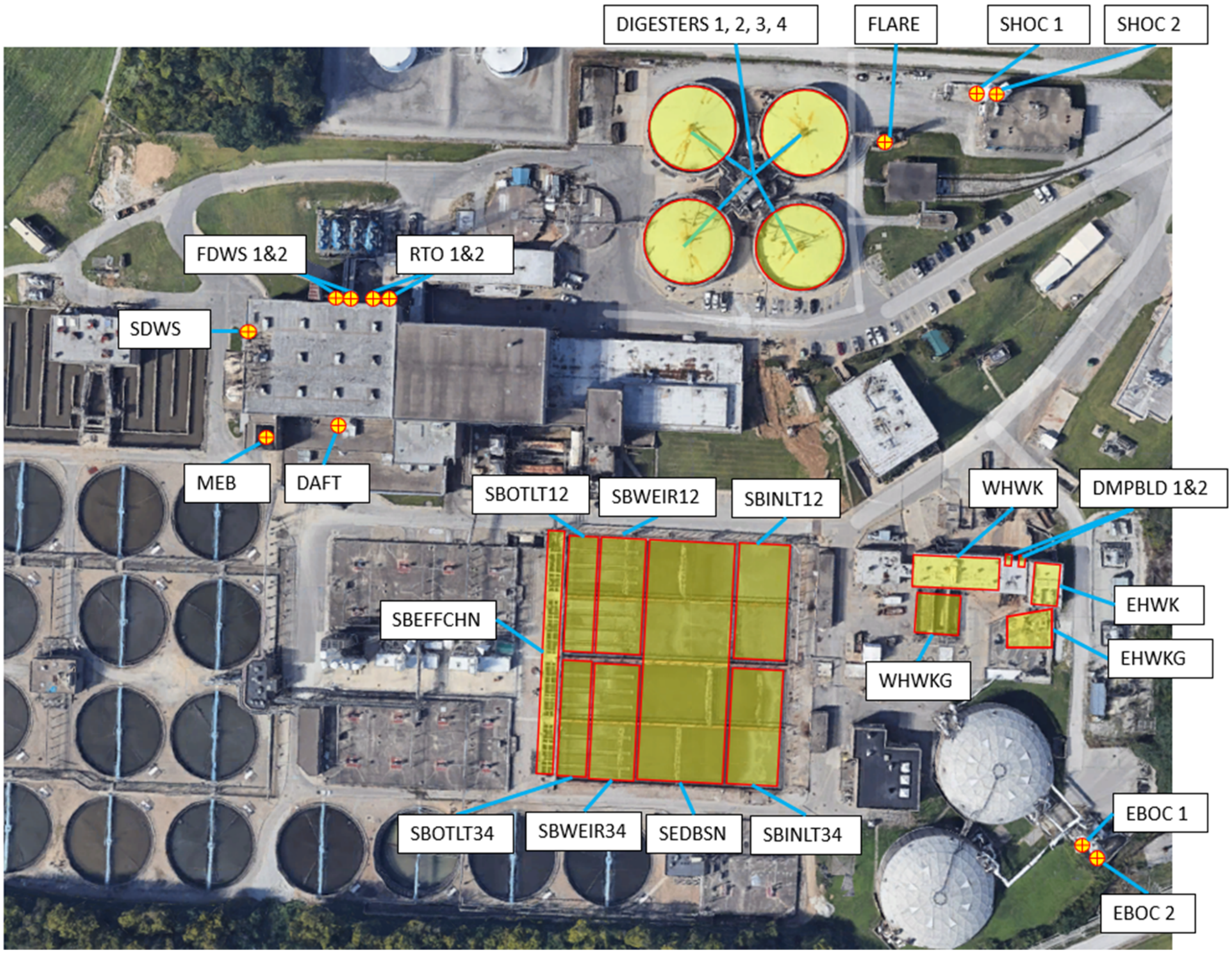

Figure 6-4 - Modeled Source Locations at MFWQTC

6.1.7 Odor Modeling Results

Odor modeling was performed based on a 10-min averaging period and was compared to a 20 OU/m^3 threshold. Odor impacts above a specified odor threshold that occur less than two percent of the hours in a year (i.e., 175 hours/year) would not be considered significant based on the Institute of Air Quality Management Guidance on the Assessment of Odor for Planning[5].

Odor modeling was performed using a five-year meteorological database (2017-2021) provided by Kentucky's Division for Air Quality. AERMOD was used to estimate maximum ground-level odor concentrations outside the MFWQTC fence line. For this application, 1-hour emission rates were extrapolated down to 10 minutes using the power law function referenced above.

The modeling results for the current configuration are provided in Table 6-3. Table 6-3 shows the highest modeled odor concentrations by source group and then for all sources combined. Based on the results of the model, the Sedimentation Basin and BOC are the two biggest contributors to odor impacts.

[5] Bull, M., A. McIntyre, D. Hall, G. Allison, J. Redmore, J. Pullen, L. Caird, M. Stoaling, R. Fain, (2014). IAQM Guidance on the assessment of odour for planning, Institute of Air Quality Management, London. www.iaqm.co.uk/text/guidance/odour-guidance-2014. April.

A graphical depiction of the 10-minute odor modeling results is provided in Figure 6-5. The contours on this plot reflect frequency of time over the five-year modeled period in which the odor threshold of 20 OU/m^3 was exceeded at each receptor point.

The maximum frequency of exceedance of 20 OU/m^3 is approximately 24.5% of time. However, these highest impacts are immediately on the property line of the MFWQTC and do not stretch into residential areas.

Table 6-4 and Figure 6-6 show results with the assumption of a 98% decrease in odor emissions from the Sedimentation Basin, based on the upgrades described in Section 4.1.4.1. The maximum frequency of exceedance of 20 OU/m^3 with that assumption in place is 13.0% of time, with highest impacts also on the immediate property line of the facility.

Table 6-3 - Odor Modeling Results – Current Configuration at MFWQTC (Culpability)

Source	Highest Concentration (H1H in D/T)	Date of H1H	Receptor Location
Source Group			
SHOC	310.54	6/29/20 at 22 hrs	602126.48, 4232146.24
RTO	3.23	1/27/20 at 03 hrs	601775.35, 4231824.95
DWS	55.58	7/05/21 at 07 hrs	601997.19, 4232120.01
BOC	703.38	6/28/19 at 23 hrs	602214.35, 4231912.77
FLARE	5.39	2/24/19 at 08 hrs	602278.54, 4232125.65
DAFT	37.91	6/01/21 at 07 hrs	601880.90, 4232121.56
MEB	119.70	8/02/18 at 07 hrs	601880.90, 4232121.56
DIG	0.01	8/02/18 at 07 hrs	602041.01, 4232148.85
HDWK	49.40	11/16/18 at 20 hrs	602199.24, 4231996.91
ASEDBSN	1518.89	3/21/21 at 08 hrs	601733.78, 4232010.83
ALL	1557.59	8/13/18 at 07 hrs	601842.13, 4232122.08

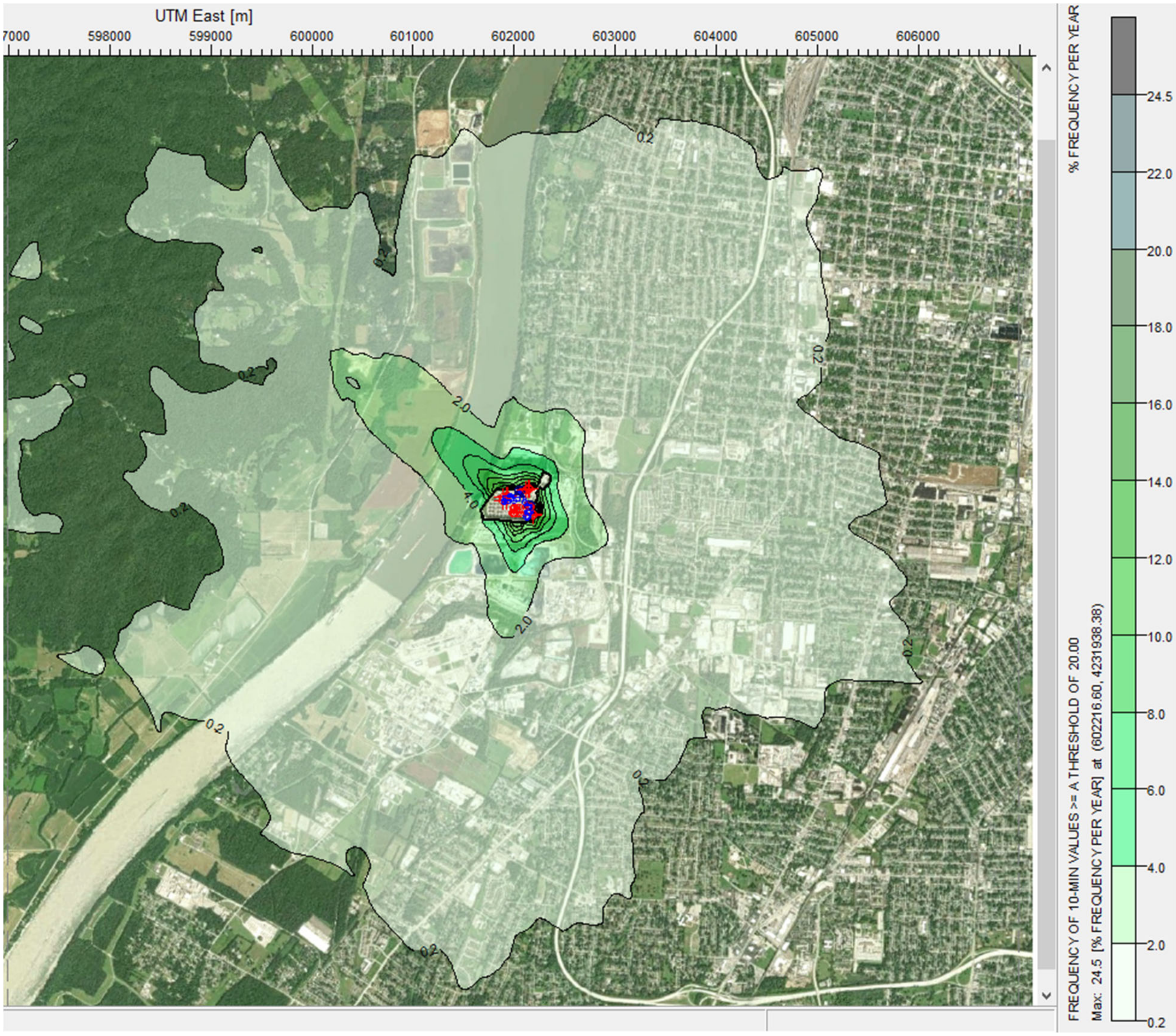

Figure 6-5 - Odor Modeling Results, Frequency – Current Configuration at MFWQTC

Table 6-4 - Odor Modeling Results – Assumption of Sedimentation Basin Control at MFWQTC (Culpability)

Source	Highest Concentration (H1H in D/T)	Date of H1H	Receptor Location
Source Group			
SHOC	310.54	6/29/20 at 22 hrs	602126.48, 4232146.24
RTO	3.23	1/27/20 at 03 hrs	601775.35, 4231824.95
DWS	55.58	7/05/21 at 07 hrs	601997.19, 4232120.01
BOC	703.38	6/28/19 at 23 hrs	602214.35, 4231912.77
FLARE	5.39	2/24/19 at 08 hrs	602278.54, 4232125.65
DAFT	37.91	6/01/21 at 07 hrs	601880.90, 4232121.56
MEB	119.70	8/02/18 at 07 hrs	601880.90, 4232121.56
DIG	0.01	8/02/18 at 07 hrs	602041.01, 4232148.85
HDWK	49.40	11/16/18 at 20 hrs	602199.24, 4231996.91
ASEDBSN	30.38	3/21/21 at 08 hrs	601733.78, 4232010.83
ALL	703.54	6/28/19 at 23 hrs	602214.35, 4231912.77

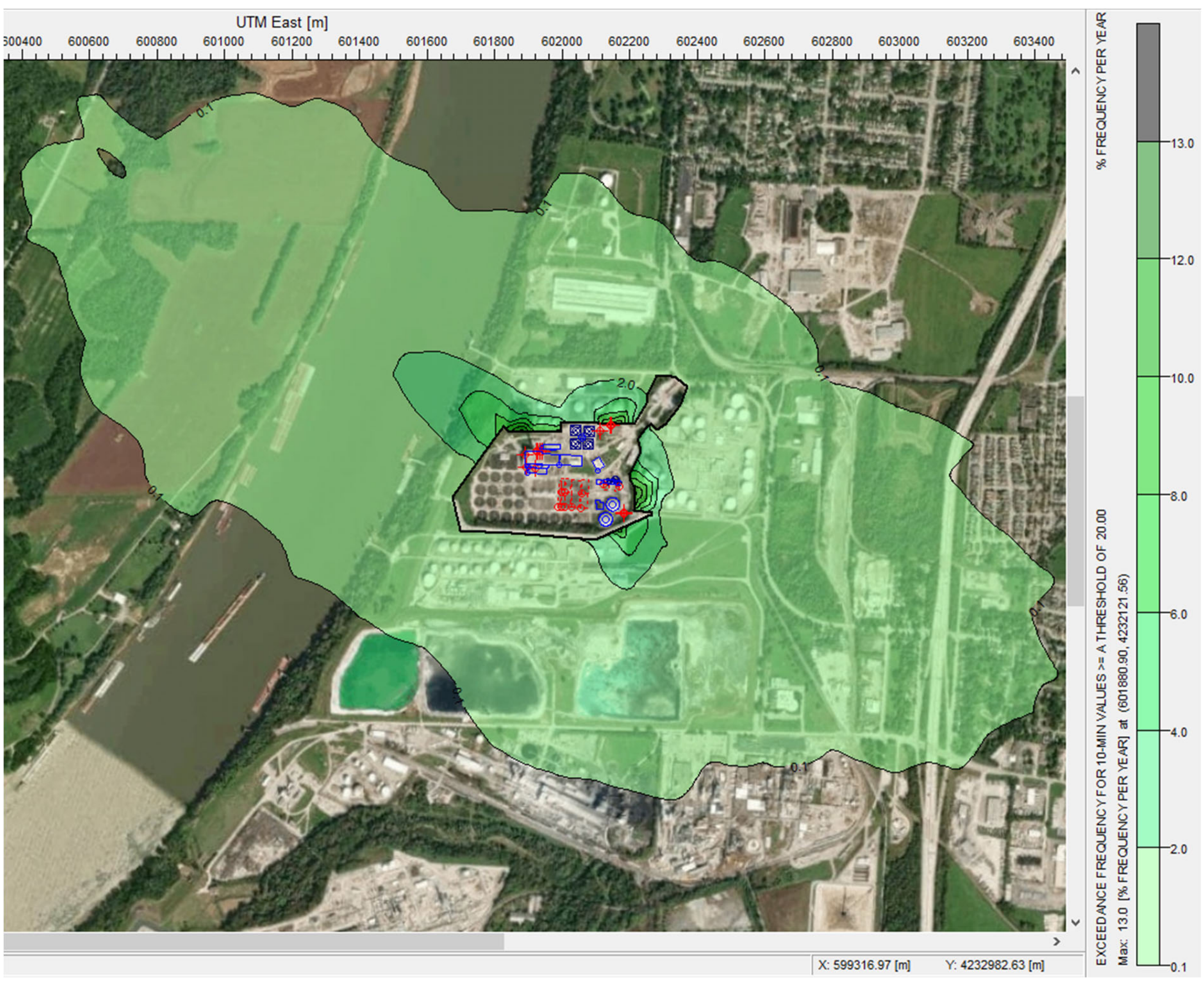

Figure 6-6 – Odor Modeling Results, Frequency – Assumption of Sedimentation Basin Control at MFWQTC

6.2 Pump Station #4 Modeling

Air dispersion modeling was also performed for Pump Station #4. Results of that modeling analysis are provided in the following sub-sections.

6.2.1 Modeling Methodology

The modeling methodology was the same used for MFWQTC, as described in Section 6.1.1.

6.2.2 Rural/Urban Dispersion Environment

The Rural/Urban designation process was the same used for MFWQTC, as described in Section 6.1.2. Based on visual inspection of aerial imagery (see Figure 6-7), land cover within 3 km (1.86 miles) of the pumping station is more than 50 percent rural land type. Therefore, the proposed project is considered rural and AERMOD was run in default model without any consideration of any urban source options for all sources modeled.

Figure 6-7 - Aerial Map of 3-km/1.86-mile Radius around Pump Station #4

6.2.3 Meteorological Data

The meteorological data used for modeling Pump Station #4 was the same used for MFWQTC, as described in Section 6.1.3.

6.2.4 Building Downwash

The latest version of the EPA Building Profile Input Program (BPIP-PRIME) was run to determine dominant structures for building downwash in AERMOD for the point sources that have the capability of emitting odorous compounds. These point sources at the pump station consist of two exhaust ports. For these sources, direction-specific building heights and widths of the dominant downwash structure were included in the AERMOD model and input file directly from BPIP-PRIME output. The locations of these sources are with respect to the specific building included in the BPIP-PRIME modeling are shown in Figure 6-9.

6.2.5 Receptor Locations and Terrain Processing

The receptor grid for the pump station was applied in the same manner as described in Section 6.1.5, with the exception of the receptor spacing at the facility boundary. Because of the shorter boundary line, a 25-m increment was used along the fence line, and 3,849 total receptors were used in the analysis, as shown in Figure 6-8.

Figure 6-8 - Location of AERMOD Modeled Receptors around Pump Station #4

6.2.6 Source Data and Modeling Inputs

The two odorous sources at the pump station are described in Table 6-5, with the same emission calculation process used for MFWQTC modeling as described in Section 6.1.6. Emission calculations were based on odor concentrations obtained using the average of two sensors located in the lower level of the pump station building.

Table 6-5 - Proposed Emissions and Stack Parameters for Dispersion Modeling – Point Sources at Pump Station #4

EMISSION DESCRIPTION	SOURCE ID	CORRESPONDING SENSOR NUMBER Used for D/T Emissions(1)	STACK HEIGHT (ft)	STACK TEMPERATURE (F)	FLOW RATE (ACFM)(2)	STACK DIAMETER (ft)	ODOR CONCENTRATIONS (D/T - dilution to threshold)	Emission Rate 10-MIN "mega"OU/sec
Exhaust Port 1	EP1	N/A	21.0	Ambient	8,000	2.26	8,475	4.5788E-02
Exhaust Port 2	EP2	N/A	21.0	Ambient	8,000	2.26	8,475	4.5788E-02

(1) Odor Concentration is based on an average of two sensors located in the lower level of the building.
(2) Flow rate is based on 2 Type BC Centrifugal fans.

Figure 6-9 - Modeled Source Locations at Pump Station #4

6.2.7 Odor Modeling Results

The modeling results for Pump Station #4 are provided in Table 6-6 and the location of the receptor with the highest concentration is on the property line of the facility.

A graphical depiction of the 10-minute odor modeling results is provided in Figure 6-10. The contours on this plot reflect frequency of time over the five-year modeled period in which the odor threshold of 20 OU/m^3 was exceeded at each receptor point. The maximum frequency of exceedance of 20 OU/m^3 is approximately 30.9% of time, with the highest impacts just

North/Northwest of the pump station, while areas with more than 2% frequency of exceedance are modeled to occur in all directions within 100 – 400 meters surrounding the facility.

Table 6-6 - Odor Modeling Results –Pump Station #4 (Culpability)

Source	Highest Concentration (H1H in D/T)	Date of H1H	Receptor Location
EP1	1,748.20	11/18/2018 at 06hrs	608941.37, 4224099.32
EP2	1,844.30	11/18/2018 at 06hrs	608941.37, 4224099.32
BOTH SOURCES	3,592.50	11/18/2018 at 06hrs	608941.37, 4224099.32

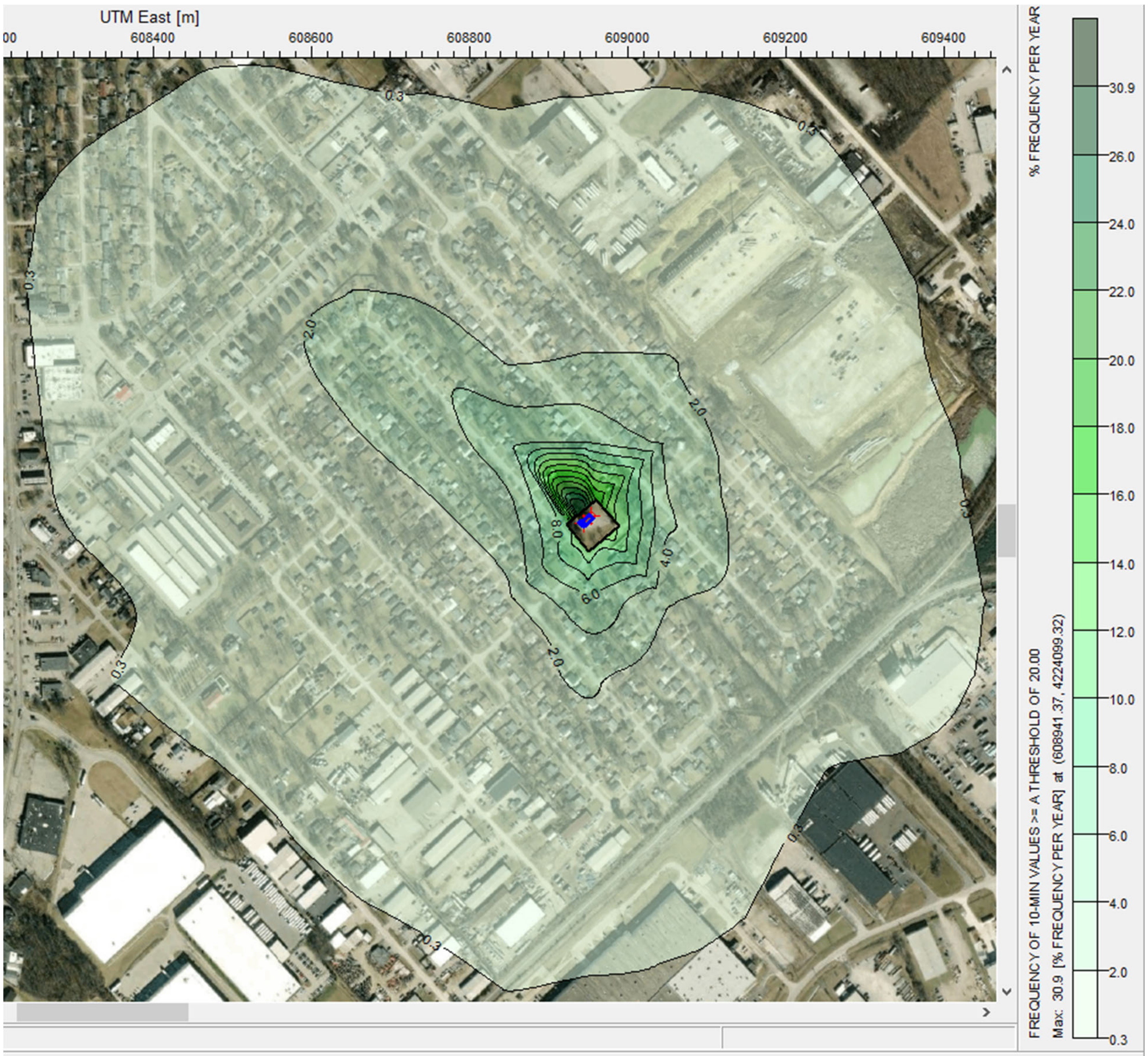

Figure 6-10 – Odor Modeling Results, Frequency – Pump Station #4

7. Selected Odor Control Design Concepts

Various odor control technologies were evaluated and selected for locations within the Morris Forman WQTC, collected system and selected pump stations. The sub sections below describe the technology recommended for each location. TM #9 contains additional details, including location maps and concept drawings for the proposed odor control systems.

Recommendations made for each system are based on information known at the time of master plan development. Additional investigation will need to be performed for each area to confirm feasibility of installing the recommended units. As a result, recommendations are subject to change as new information becomes available.

7.1 MFWQTC Odor Technology Recommendations

7.1.1 Sedimentation Basins/BOC System

The sampling results for the sedimentation basins, fully described in TM #6A, indicate that odor and H_2S levels are high at this location. MSD is currently working with a design engineer to incorporate odor control on the sedimentation basins. The proposed system involves rehabilitation of the biotrickling filters and replacement of the media. This new odor control system should remove 99.9% of H_2S but is not designed to reduce odor. A second treatment stage may be considered to handle odor as part of the rehabilitation program. It is recommended that the upgraded system should have an allowance for increased air flow treatment rate, if necessary. Once the new odor control system is installed, during the commissioning a performance test is recommended to confirm removal efficiency. A multi-media carbon unit is recommended to be installed on the BOC to reduce the odor emission concentration.

7.1.2 East and West Headworks

The East and West Headworks buildings and grit channels were all sampled as part of the recent sampling campaign (see TM #6A). The results indicate high odor and H_2S levels are present within the East and West Headworks. In order to mitigate these odor issues, it is recommended that covers are installed on the open channel portions of the flow train, and a biofilter with synthetic media is installed for the Headworks. The Biofilter and media would be designed to reduce both the odor and H_2S levels within the East and West Headworks, but the Biofilter would require a larger footprint that may not be available at the Headworks area. A biotrickliing filter could be installed instead of a biofilter since it is more of a tower installation and typically requires less of a footprint. A biotrickling filter may also need carbon polishing incorporated as well to further reduce odor emissions.

7.1.3 DAFT/Main Equipment Building Exhaust

The DAFT system and Main Equipment Building exhaust at the Morris Forman WQTC had high odor levels during the recent sampling campaign. In order to reduce the odor, a biotrickling filter is recommended at this location. The proposed unit would manage the high odor levels present in the DAFT unit and Main Equipment Building exhaust.

7.1.4 SHOC

The SHOC had high H_2S and TRS removal efficiency, but air dispersion modeling described in Section 6 showed the SHOC had a large impact on the overall odor contribution in the surrounding area. Therefore, it is recommended that additional odor control units be considered here. A multi-media carbon unit is recommended to be added to reduce odor emissions from the SHOC.

7.1.5 RTOs

Testing performed as part of commissioning of the RTOs indicated that the percent odor reduction was high, but the methyl mercaptan and dimethyl disulfide concentrations were elevated. Air dispersion modeling results do indicate that the RTOs do not contribute a large amount of odor to the surrounding area. As a result, no additional odor control is recommended for the RTOs. These units can be re-evaluated in future phases of the odor control master plan if deemed necessary.

7.1.6 Fugitive Dust Wet Scrubber

Testing performed as part of commissioning of the Fugitive Dust Wet Scrubber indicated that the units had high odor, methyl mercaptan, dimethyl disulfide, and ammonia concentrations. The Fugitive Dust Wet Scrubber was also shown in the air dispersion model to have a moderate impact on the surrounding community. However, no additional odor control is currently recommended for the Fugitive Dust Wet Scrubbers. This system can be re-evaluated in future phases of the odor control master plan if deemed necessary.

7.2 Collection System Odor Technology Recommendations

7.2.1 Grand Avenue Force Main Pilot Study

Bioxide is currently injected at five (5) locations within the Morris Forman collection system; however, based on the sampling results, the Bioxide, which is intended to mitigate high H_2S within the force mains, is not performing as intended (see TM #7B). The sampling results in TM #6B indicate that both H_2S and odor values were high within the Ohio River Force Main.

Since the Bioxide system is not performing as intended, a pilot study for an alternate chemical is recommended to be performed on the Grand Avenue Force Main. The Pilot study would be initially deployed on the Grand Avenue Force Main, and if deemed successful, could be incorporated full scale on the ORFM. The chemical to be used for the pilot study will need to be determined after further evaluation of the force main layout/configuration, and characteristics of the flow within the force main. The selected chemical would be evaluated for effectiveness of reducing both odor and H_2S levels, as well as providing extended benefits for a longer length of pipe.

7.2.2 Western Outfall Pilot Study

The Western Outfall is routed through two (2) of the neighborhoods specifically named in the Notice of Violation; California and Chickasaw. Both of these neighborhoods frequently experience nuisance odors, and a large number of odor complaints are generated from these two neighborhoods. The sampling results, fully described in TM #6B, indicate that the manholes located on the Western Outfall contain high odor and H_2S levels. In addition, this sewer runs at positive pressure, which means that all of the nuisance air is expelled from the sewer headspace at the various manhole points along the pipe. This gravity sewer, which ranges in size between 60” and 141”, is a prime candidate for a negative pressure pilot unit installation. The negative pressure unit could be installed at one or more locations along the sewer to keep the pipe running at negative pressure, so that the nuisance air is carried downstream towards the Morris Forman WQTC. The number of units running concurrently would depend on unit availability from the vendor, as well as MSD’s budget to perform the pilot testing. Once the pilot unit is installed, sampling can be repeated at the same locations sampled as part of this Master

Plan effort, to see if impact the pilot unit has on the results. A conceptual layout is provided in TM #9. If the pilot unit proves successful, a similar pilot or a full-scale unit could be installed on the Ohio River Interceptor and the Southern Outfall, both which also had high odor and H_2S levels and are routed through neighborhoods listed in the Notice of Violation.

7.3 Pump Stations Odor Technology Recommendations

7.3.1 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, a hydroxyl generator or photoionization unit are recommended for odor removal at this facility.

Two (2) hydroxyl generators, with air intake capabilities of 1,000 CFM, would be installed along the northwest wall of the facility, each handling the exhaust of two (2) wet wells. Exhaust from each of the four (4) wet wells would be treated through 4" diameter pipes connected to the hydroxyl generators. The hydroxyl enclosure dimensions are 7.5' x 24'. Two additional 10" diameter goose neck vents would be installed within the wet wells, along with a new air supply and exhaust system for the overall pump station.

The photoionization unit would be installed along the northeast wall of the facility and have a capacity of 10,000 CFM, an intake pipe of 36" diameter, and a chamber with the dimensions 18' x 10'. A supply air plenum would be installed within the existing pump station to facilitate air distribution, in addition to an exhaust plenum for supplying air to the new photoionization unit.

Schematic conceptual designs for both units are provided in TM #9.

7.3.2 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 are recommended for odor removal at this facility.

The multi-layer carbon unit would be installed along the east wall of the facility and have a treatment capacity of 9,500 CFM, a 36" diameter intake duct, and a new air intake system for supplying wet well exhaust to the new multi-layer carbon unit.

Two (2) hydroxyl generators, with air intake capabilities of 1,000 CFM, would be installed along the east wall of the facility. Hydroxyl radicals would be dispersed through 4" diameter pipes to treat the exhaust from each of the four (4) wet wells. The hydroxyl enclosure dimensions are 7.5' x 24'.

Schematic conceptual designs for both units are provided in TM #9.

7.3.3 Pump Station #8

Pump Station #8 is located on the northern end of the Morris Forman service area, just west of the 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 are recommended for odor removal at this location.

The photoionization unit would be installed along the south wall of the facility and have a 6,000 CFM capacity, a 14" diameter intake duct collecting air from the pump room, and a chamber with the dimensions 16' x 9'. Two (2) air supply plenums would be installed on the north and south walls of the pump room to facilitate air distribution.

The hydroxyl advanced oxidation unit would consist of 2 separate Vapex units along the east wall of the pump room. Each Vapex unit would have an 8" diameter pipe with a spray head for dispersing Hydroxyl radicals to treat wet well exhaust. Two (2) air supply plenums would additionally be installed on the north and south walls of the pump room to facilitate air dispersion.

Schematic conceptual designs for both units are provided in TM #9.

7.3.4 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.

The photoionization unit would be installed along the southeast wall of the facility and have a 9,000 CFM capacity, a 36" diameter air intake duct collecting air from the pump room, and a chamber with the dimensions 15' x 9'. An additional air intake vent would be installed to supply air to the photoionization unit.

The biotrickling unit would be installed along the southeast wall of the facility and would have a treatment capacity of 9,000 CFM. It would be 11' 6" x 27' in size, have a 36" diameter air intake duct, and a new air supply system to ventilate wet well exhaust to the biotrickling unit.

Schematic conceptual designs for both units are provided in TM #9.

7.3.5 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 is recommended to reduce the odor and H_2S levels.

The biotrickling unit would be installed along the southeast wall of the facility and would have a treatment capacity of 9,000 CFM. It would be 11' 6" x 27' in size, have a 36" diameter air intake duct, and a new air supply system to ventilate wet well exhaust to the biotrickling unit.

The multi-layer carbon unit would be installed along the southeast wall of the facility and have a treatment capacity of 9,000 CFM, a 36” diameter intake duct, and a new air intake system for supplying wet well exhaust to the new multi-layer carbon unit.

Schematic conceptual designs for both units are provided in TM #9.

8. Conclusions / Action Items

The previous section of this Master Plan report discussed the recommendations for odor control implementations within the MFWQTC, Morris Forman collection system, and select pump stations. A summary of the recommendations for each area is summarized in Table 8-1.

Table 8-1– Summary of Odor Control Technology Recommendations

Location	Recommended Odor Control Technology
Morris Forman WQTC	
Sedimentation Basin/BOC	Multi-media carbon unit
East and West Headworks	Installation of covers on open channels, and Biofilter with synthetic media or Biotrickling unit.
DAFT/Main Equipment Building	Biotrickling Filter
SHOC	Multi-media carbon unit
Collection System	
Grand Avenue Force Main	Chemical Injection Pilot Study
Western Outfall	Negative Pressure Pilot Study
Pump Stations	
Pump Station #4	Two hydroxyl generators or photoionization unit
Pump Station #6	Multi-layer carbon unit or two hydroxyl generators
Pump Station #8	Photoionization Unit or Biotrickling Unit
Pump Station #2	Photoionization Unit or Biotrickling Unit
Pump Station #3	Biotrickling Unit or Multi-layer carbon unit

The odor control technology recommendations were based on an evaluation of the odor sampling data collected at each facility. A review of applicable odor removal technologies was completed at each facility and specific technology recommendations were made specific to the sampling data at the specific facility with a focus on constituents and concentrations of the odor causing compounds. In addition, odor control technology vendors were contacted to provide their recommendations. Due to the technology evaluation recommendations at each facility, the following action items and next steps have been identified to continue implementation.

- Develop a plan with MSD to implement the two pilot studies in the collection system involving a negative pressure unit with odor control placed within the large Western Outfall. Also, review the second pilot with MSD, a second chemical dosing evaluation using an alternative chemical. Each pilot's effectiveness will be evaluated over two months to study each option's effectiveness. After the pilot study data's evaluations, a decision will be made on implementing the two piloted technology solutions.
- Evaluate each odor control technology at each pump station facility and at the designated Morris Forman WQTC process areas and review recommendations for further feasibility and space availability for incorporating the units specified, and as discussed with MSD.
- The facilities with two recommended technologies should also move forward with developing a preliminary design for each alternative and a preliminary cost estimate with operating costs. Select the preferred alternative based on the cost estimate and net present value analysis.

- Determine a schedule and phasing approach for implementing design and then construction of new odor control upgrades at the various facilities based on budgets available and other factors evaluated based on discussions with MSD.
- Begin Phase 1 implementation

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