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Memo

Subject: Technical Memorandum #1- Morris Forman WQTC Background Document Review

1. Introduction

The Morris Forman Water Quality Treatment Center (MFWQTC) is equipped with various odor control systems for treatment of foul air from multiple process areas. Since the plant was commissioned in 1958, the Louisville and Jefferson County Metropolitan Sewer District (MSD) has performed several odor control projects and planning studies at the MFWQTC to mitigate offline odor impacts within the community. In 2001, MSD contracted CH2M Hill (Jacobs) and Webster Environmental Associates, Inc. (WEA) to evaluate odor and H_2S emissions at specific locations and develop odor control recommendations as part of the 2001 Odor Control Master Plan (OCMP). Based on the findings of the 2001 OCMP and follow-up testing by CH2M Hill (Jacobs) and WEA in 2006, MSD completed the following odor control improvements:

- Screw Conveyor improvements at the Main Equipment Building – 2006
- Replacement of leaking digester air release valves – 2007
- Replacement of chemical scrubbers serving Bioroughing towers with Biotower Odor Control (BOC) biotrickling scrubbers provided by Bioway – 2007
- Replacement of fume incinerators with Solids Handling Odor Control (SHOC) biotrickling scrubbers provided by Biorem– Installed in 2006, rebuilt in 2011; one of the fume incinerators remained as a backup until December 2017 when it was decommissioned
- Collection of air from Truck Unloading Station (TUS) and treatment in the SHOC biotrickling scrubbers – 2007
- Upgrades to the existing grit channel covers – 2008

Following the completion of these projects, MSD contracted CH2M Hill (Jacobs) and WEA to perform follow-up odor testing and field sampling, update the dispersion modelling, and development of recommended odor control improvements. The findings of the study were outlined in the OCMP Update report and dated February 2009. Proceeding the 2009 OCMP Update recommendations, MSD is currently in the process of completing the Dryer Replacement Project (Contract No. 16453) which involves replacing the existing odor control systems at the Main Equipment Building. In addition, MSD installed new equipment at the East and West Headworks under Contract No. 15677.

MSD is currently in the preliminary design stages of the Rehabilitation and Replacement of Primary Sedimentation Basins and Related Equipment Project. As part of this project, MSD plans on implementing odor collection and treatment processes at the primary sedimentation basins and aerated influent channel. In August 2020 Greeley and Hansen performed detailed field testing to assess existing odor emissions at specific locations within the sedimentation basins and aerated influent channels. In September 2020 the consultant submitted the 30%design package which included the Basis of Design Report (BODR), drawings, list of specifications and preliminary cost opinions.

Completed and ongoing odor control projects are documented in various reports, testing data, and record plans. As part of the initial phases of the OCMP Update, AECOM performed a detailed review and evaluation of documentation related to odor control improvements at the MFWQTC. This TM summarizes each background document available and provides recommendations for the path forward to mitigate the odor emissions from MFWQTC. For more details involving MFWQTC process modifications, please refer to TM#4 (currently in development) which will be made available at a later date.

2. Summary of Documents Reviewed

Available documents related to odor control at the MFWQTC were reviewed and evaluated. These documents are summarized and presented chronologically in this Section of the report.

2.1 Headworks Modifications Drawings (1998)

In 1998, a new Headworks system was installed at the MFWQTC under Contract No. 12779. CH2M Hill / Quest was the design team for these improvements. The project included installation of a new influent diversion box, influent Parshall flumes, new screening facility, grit removal facility, aeration system and drainage pumping. The existing screening and grit removal facilities were kept for treating Wet Weather Flow and redundancy. Existing Grit Channel No. 4 and aeration piping was removed. The 1998 Headworks record drawings also show demolition plans which overlay the original 1985 Headworks drawings.

2.2 Odor Control Master Plan (CH2M Hill/ WEA, 2001)

CH2MHill (Jacobs) and WEA were contracted to perform an evaluation of point and non-point odor sources throughout the MFWQTC. This document is now considered the 2001 Odor Control Master Plan. The study was initiated to determine potential offline impacts from remaining odor sources after the Zimpro sludge conditioning process was de-commissioned. Gas and liquid phase sampling and H_2S monitoring was performed at (14) locations during two conditions: a) with ferric chloride dosing and b) without ferric chloride dosing. Ferric chloride dosing is considered normal operating conditions. It should be noted that the report did not provide the ferric chloride dosing rate utilized during the sampling period. The sampling locations are summarized below:

1. Old Headworks Influent Channel
2. New Aerated Influent Box
3. New Grit Channels
4. Old Headworks Effluent Channel
5. Primary Influent Channel
6. Primary Clarifier Surface
7. Primary Clarifier Effluent Weirs
8. Primary Clarifier Effluent Channel
9. Unox Influent Channel
10. Effluent Channel
11. New Grit Classifier Room Exhaust
12. Screen and Grit Dumpster Room Exhaust
13. Biotower Scrubber Stack A
14. Biotower Scrubber Stack B

Table 2-1 summarizes the highest contributors to the total odor and hydrogen sulfide (H_2S) emission rate for each of the two ferric chloride ($FeCl_2$) dosing conditions. It should also be noted that the scrubbers were not operating within proper pH and ORP range during the sampling period.

Table 2-1 Highest Odor and H_2S Sources, OCMP 2001

	Top Odor Sources (% of Total Odor Emission Rate)	Top H_2S Sources (% of Total H_2S Emission Rate)
With Ferric Chloride Dosing	(1) Biotower Scrubbers, 44% (2) Primary Clarifiers, 19% (3) Unox Effluent Mixed Liquor Channel, 13%	(1) Primary Clarifier Surface, 52% (2) Plant Influent Channel, 11% (3) Unox Effluent Mixed Liquor Channel, 9%
Without Ferric Chloride Dosing	(1) Biotower Scrubbers, 44% (2) Plant Influent Channel, 10% (3) Aerated Primary Influent Channel,10%	(1) Primary Clarifier Surface, 27% (2) Plant Influent Channel, 17% (3) DAFT Room Exhaust, 13%

Using the odor sampling results, the ferric chloride dosing efficiency was determined at sampling locations. **Table 2-2** presents a comparison of odor sampling results in D/T for each of the ferric chloride scenarios and the estimated percent odor reduction. Since the Old Headworks was used in the "With Ferric Chloride" condition and the New Headworks was used in the "Without Ferric Chloride" condition, direct comparisons could not be made at the Headworks. In addition, the Unox system at the Mixed Liquor effluent channel and Biotower Scrubber A were both inoperable during the "Without Ferric Chloride" condition and therefore were not included in the dosing efficiency analysis.

Table 2-2 Ferric Chloride Dosing Efficiency, OCMP 2001

Sample Location	Dilutions to Threshold (D/T)			H_2S Concentration (ppm)		
	Without $FeCl_2$ Dosing	With $FeCl_2$ Dosing	% Reduction[1]	Without $FeCl_2$ Dosing	With $FeCl_2$ Dosing	% Reduction[1]
Primary Influent Channel	4,500	1,400	69%	5.2	0.24	95%
Primary Clarifier Surface	1,300	2,600	N/A	0.92	2.8	N/A
Primary Effluent Weirs	4,100	3,200	22%	2.2	2.9	N/A
Primary Effluent Channel	2,900	2,300	21%	1.0	5.3	N/A
Biotower Scrubber B	2,900	1,400	52%	17.7	0.1	99%

[1] Percent Reduction = ([Without $FeCl_2$ Dosing] – [With $FeCl_2$ Dosing])/ [Without $FeCl_2$ Dosing]

Table 2-2 shows a range of odor reduction efficiency at the various sampling locations, ranging from 21% at the primary effluent channel, to 69% at the primary influent channel. At the primary clarifier surface sample location, ferric chloride dosing failed to improve D/T. Ferric chloride was successful at reducing H_2S concentration by 95% at the primary influent channel and 99% at Biotower Scrubber B. However, sampling data showed that H_2S concentrations were higher at each of the primary clarifier sampling locations when ferric chlorine dosing was performed. Overall, these findings suggest that ferric chloride dosing efficiency was inconsistent and generally ineffective at odor control at the primary clarifiers during the sampling period.

Dispersion modelling was performed using odor concentration sampling data to assess offline odor impacts from various odor control scenarios. The desired peak community odor level criteria was fewer than 100 odor events per year.

A total of five (5) offline odor receptors were evaluated which were located north, northeast, east, southeast, and south of the MFWQTC. **Table 2-3** summarizes the model scenarios and subsequent offline impacts at two of the odor receptor locations that showed the highest peak D/T values (northeast at South end of Cecil) and highest event frequency (south at Bells Ln) across the five receptor locations. The table also includes the range of percent reduction between the baseline scenario and each odor control alternative for the two specified receptor locations. It is also important to note that Biofiltration was the recommended odor control alternative included as Alternative 4 due to cost analysis, however the technology removal efficiency, reliability, and cost screening were not included in the report.

Table 2-3 Dispersion Modelling Results, OCMP 2001

Alternative #	Description	Peak Odor Concentration (D/T)			Odor Event Frequency (#/ yr)		
		South end of Cecil (Northeast)	Bell Ln. (South)	% Reduction[1]	South end of Cecil (Northeast)	Bell Ln. (South)	% Reduction[1]
Baseline	Scrubbers are not operating within pH or ORP range)	149	54	**-**	88	454	-
1	Scrubbers Optimized (Operating within pH or ORP range)	149	39	**0-28%**	31	315	**31-65%**
2	Odor Control on Headworks	101	38	**30-32%**	20	180	**60-70%**
3	Odor Control on Channels, Optimized Ferrous Chloride Dosing	68	23	**54-57%**	13	136	**70-85%**
4	Odor Control on Headworks and Channels, Alternative Odor Control at Biotowers (Biofiltration)	101	38	**30-32%**	17	138	**70-81%**

[1] Percent Reduction = ([Baseline] – [Alternative])/ [Baseline]

Modelling results showed that Alternatives 3 and 4 achieved the desired peak community odor level criteria of an average odor event frequency fewer than 100 odor events per year. In Alternatives 1 and 2, community odor levels could remain a problem with an average odor event frequency greater than 100 events per year and therefore were not recommended. Preliminary costs were also developed for each odor control alternative; Alternative 4 was predicted to require the highest capital cost of $3.6 Million (2001 USD) while the capital cost for Alternatives 2 and 3 was $1.6 Million. Estimated annual O&M costs were highest for Alternative 3 with approximately $500,000 per year and lowest for Alternative 4 with an estimated $60,000 per year.

Based on the findings from the dispersion modelling and economic analysis, an implementation strategy was provided including short term and long term recommendations.

Short-term Recommendations

- Evaluate if sludge detention time at primary clarifiers can be reduced
- Perform operational adjustments and testing at Biotower scrubbers

- Re-run the dispersion model using a more representative emission rate at the Unox MLSS effluent channel
- Conduct bench testing to determine optimal FeCl2 dose
- Evaluate alternate cost-effective odor control methods at Headworks

Long-term Recommendations

- Odor control at Headworks and Channels
- Ferrous chloride dosing optimization based on bench testing

2.3 Odor Control Master Plan Follow-up Testing Report (CH2M Hill/ WEA, 2007)

Written as a follow-up to the 2001 OCMP, CH2MHill and WEA performed gas phase sampling and H_2S monitoring at six (6) locations that would be impacted by completed and near-term odor control projects. Sampling data was incorporated into an updated dispersion model which showed potential offline impacts of completed and ongoing odor control projects. The following list outlines the odor control projects that had been completed or ongoing at the time of the 2006 OCMP follow-up report:

1. Screw Conveyor improvements at the Main Equipment Building (Completed in 2006)
2. Installation of SHOC biotrickling scrubbers to replace existing fume incinerators (Ongoing as of 2006)
3. Collection and treatment of air from Truck Unloading Station (TUS) Odor Control Project via SHOC biotrickling scrubbers (Ongoing as of 2006)
4. Collection and treatment of air from Solids Receiving Tanks (SRTs) via SHOC biotrickling scrubbers (Ongoing as of 2006)
5. Leaking digester air release valves were replaced (Completed)

Screw conveyor improvements (Contract No. 14955) involved repair and replacement of all screw conveyor covers from the centrifuges to the dryer system and installation of a fan and ductwork to collect air from these conveyers and treat at the biotrickling scrubbers. Under the same contract, the new SHOC biotrickling scrubbers were to be installed to replace the fume incinerators adjacent to the Headworks, which was ongoing as of 2006 (refer to **Section 2.5** for project details). At the time this report was written, the TUS Odor Control project (Contract No. 2006-09) was also under construction.

Gas phase sampling and H_2S monitoring was focused on the screw conveyor modifications (Item 1 above) as well as ongoing/future projects 2 through 4 above. The air samples were collected at the following six (6) locations:

1. 6^{th} floor roof fans with conveyor lids closed
2. 6^{th} Floor roof fans with conveyor lids open
3. Exhaust Dust from Conveyors 11 and 12
4. Truck Unloading Station (TUS) when Jefferson Town was unloading
5. DAFT Exhaust Fan
6. MEB Exhaust

Table 2-4 shows the odor emission rate and percentage of total odor emission rate at each of the (6) sampling locations, before and after recent and ongoing improvements. The report assumed that both the TUS Odor Control project and the replacement of digester air release valves would result in zero (0) odor emissions at those sources.

Table 2-4 Odor Emissions Before and After Improvements, OCMP Follow-up Testing Report 2007

Source	Prior to Improvements		After Improvements	
	Odor Emission Rate (DT*cfm)	% of Total Odor Emission Rate	Odor Emission Rate (DT*cfm)	% of Total Odor Emission Rate
MEB Exhaust	168,300,000	33.3%	142,120,000	59.6%
6th Floor Roof Fans (4 fans running)	156,000,000	30.9%	118,000,000	49.8%
DAFT Exhaust	98,500,000	19.5%	82,740,000	34.7%
Truck Unloading Station	76,000,000	15.0%	0	0%
MEB/SRT Fume Incinerators	6,400,000	1.3%	36,800,000	15.4%
Digester Pressure Relief Valves	84,000	0.02%	0	0%

Dispersion modelling was used to evaluate potential offline odor impacts from completed and ongoing odor control projects. Offline odor receptors were located at the entrance to the MFWQTC, and at the entrance to Whayne Supply which is located to the northeast of the MFWQTC. The model scenarios and associated offline odor impacts are summarized in **Table 2-5.**

Table 2-5 Dispersion Modelling Summary, OCMP Follow-up Testing Report 2007

Model No.	Model Description	Peak Odor Concentration (D/T)		Odor Event Frequency (#/ yr)	
		Entrance to MFWQTC	Entrance to Whayne Supply	Entrance to MFWQTC	Entrance to Whayne Supply
1	Conditions Prior to Odor Control Improvements completed since 2004	2,000	300	1,000	200
2	Conditions After Odor Control Improvements (completed since 2004 <u>and</u> ongoing projects)	150	80	700	140
3	Truck Unloading Station Only	2,000	65	N/A	N/A
4	Biotrickling Scrubbers Only using outlet D/T of 4,000	25	7	N/A	N/A
5	Biotrickling Scrubbers Only using outlet D/T of 2,000	10	0	N/A	N/A

The D/T values for Model #4 and #5 were based on target emission rates at the biotrickling scrubbers during start-up mode and after acclimation, respectively. The major findings of the follow-up testing and dispersion modelling are as follows:

- Odor emissions from the Truck Unloading Station (TUS) exceed 1,000 D/T when trucks are unloading.

- Modelling results showed a 53% reduction in odor emission for the scenario where all four (4) odor control projects are completed, and assuming that the TUS Odor Control Project is 100% effective at elimination odor emissions from the TUS.
- SHOC biotrickling scrubbers do not significantly contribute to offsite emissions if D/T is 4,000, and have no offline impact if D/T is 2,000. As a result, 2,000 D/T is the recommended at the outlet of odor treatment system.
- Completed screw conveyor improvements have been successful at reducing emission from the MEB exhaust fans.

The report recommended that the SHOC biotrickling scrubbers be operated with a target outlet odor concentration of 2,000 D/T which would not cause any odor detection in the community. Refer to **Section 2.5** for new SHOC biotrickling scrubbers installed in 2006. After further review it was determined that the recommended outlet level of 2,000 D/T was not achieved at the new SHOC biotrickling scrubbers during the 2008 follow-up odor sampling period. The 2009 OCMP Update used a D/T level of 4,100 at the (2) SHOC outlets based on odor sampling results. As result the target D/T of 2,000 is not considered achievable based on current SHOC operations. In addition, the assumption that the TUS Odor Control Project was 100% effective at eliminating odor emissions is considered an unrealistic target.

2.4 Biological Odor Control (BOC) – Bioway Biotrickling Scrubbers (2007)

The biological odor control (BOC) system was installed at MFWQTC in 2007 under MSD Contract No. 15292, replacing the existing chemical scrubbers serving the Bioroughing towers. MSD provided AECOM with the design plans and operation and maintenance (O&M) manual from the biotrickling scrubber manufacturer, Bioway. The (2) new biotrickling scrubbers, referred to as Scrubber “1” and “2”, were designed to receive and treat air from the existing Bioroughing towers and Aerated Channel. Each scrubber is equipped with a 30-ft diameter tower which contains synthetic media with biomass used for air treatment. Each scrubber includes the following items:

- PurSpring 10,000 cfm unit
- Water supply system including pumps and piping
- H2S and O2 measurement units
- Nutrient pump systems
- Air ductwork
- Electrical supply equipment
- Water recirculation system including pump and piping

The design parameters for the BOC system at MFWQTC are presented in **Table 2-6**.

Table 2-6 BOC System Design Parameters, Bioway

Design Parameter	Value
Quantity	Two (2) Biotrickling Scrubbers
Process Conditions	Continuous
Process Airflow	20,000 cfm total (10,000 cfm per scrubber)
Inlet H2S Concentration	60 ppmv (avg)/ 150 ppmv (peak)

2.4.1 *Performance Testing of Biotrickling Filter Odor Control System Serving Bioroughing Towers (Bowker and Associates, 2008)*

In 2008, performance testing was performed on the two (2) 10,000 Bioway biotrickling scrubbers. The study focused on H_2S removal efficiency, but also provided odor concentrations (D/T) and reduced sulfide measurements for each Bioscrubber inlet and outlet.

On the first day of sampling, a nutrient loading issue occurred which resulted in poor performance of Bioscrubber #2. The nutrient loading issue was fixed later that afternoon. On the following day, Bioscrubber #2 was achieving a low outlet H_2S concentration, thus H_2S monitoring and odor sampling was performed. Performance testing results are summarized in **Table 2-7**, including inlet and outlet H_2S levels and odor concentrations for each day of sampling. It is also important to note that the H_2S measuring instrument did not have the ability to record H_2S values exceeding 2 ppm, so the peak H_2S values during the monitoring period are unknown and average values may be skewed.

Table 2-7 Bioway Biotrickling Scrubber Performance Testing Summary, 2008

Sampling Day #1[1]						
Location	**H_2S Concentration (ppb)**			**Odor Concentration (D/T)**		
	Inlet	**Outlet**	**% Reduction[3]**	**Inlet**	**Outlet**	**% Reduction[3]**
Bioscrubber #1	65,561	383	99.4%	62,000	11,000	82%
Bioscrubber #2	61,113	15,464	74.7%	53,000	50,000	6%
Average	**63,337**	**7,924**	**87%**	**57,500**	**30,500**	**44 %**
Sampling Day #2						
Location	**H_2S Concentration (ppb)**			**Odor Concentration (D/T)**		
	Inlet	**Outlet**	**% Reduction[3]**	**Inlet**	**Outlet**	**% Reduction[3]**
Bioscrubber #1	29,347	182	99.4%	13,000	4,600	65%
Bioscrubber #2	31,112	155	99.5%	8,700[2]	6,200	28%
Average	**30,230**	**169**	**99.4%**	**10,850**	**5,400**	**47%**
[1]Issues with the nutrient feed pump likely caused reduced performance of Bioscrubber #2 on Sampling Day #1						
[2]It was noted in report that Bioscrubber #2 outlet odor concentration was suspect based on trend of average H_2S/reduced sulfide concentrations						
[3]Percent Reduction = ([Inlet] – [Outlet])/ [Inlet]						

The reduced sulfide sampling results showed an 85-97% removal efficiency for methyl mercaptan and a 24-40% removal efficiency for dimethyl sulfide. Based on the findings of the performance testing, the report makes the following conclusions:

- The existing biotrickling scrubbers are generally performing well; although under peak loading conditions, outlet H_2S excursions may occur.

- H_2S removal efficiency of the Bioscrubbers was approximately 99% when the inlet H_2S was below 100 ppm. During peak loading conditions up to 150 ppm, outlet H_2S exceeded the maximum range of the instrument (2 ppm) used to monitor exhaust H_2S levels.

2.5 Solids Handling Odor Control (SHOC) - Biorem Biotrickling Scrubbers (2008)

Two (2) 14-ft diameter Biorem multi-stage biological odor control systems were installed in 2006 and rebuilt in 2011 to treat air from the MEB and SRTs. One of the existing fume incinerators remained as a backup to the Solids Handling Odor Control (SHOC) system until December 2007 when it was decommissioned. Each bioreactor consists of two stages: (1) preliminary treatment in the Biotrickling stage and (2) biological oxidation via two biofilters. In Stage 1 (Biotrickling), foul air is humidified, and degradation of H_2S occurs in acidic conditions. In Stage 2, air passes through two biofilter media beds where H_2S is solubilized and bio-oxidized by microbes. Additional system components were installed as part of these improvements including:

- Media Irrigation Systems for the biotrickling filters and biofilters
- Sump heater to control sump water temperature
- Two water recirculation pumps (by others)
- One 9,200 cfm exhaust fan (by others)

Table 2-8 summarizes the design parameters outlined in the Biorem O&M Manual:

Table 2-8 SHOC System Design Parameters, Biorem

Design Parameter	Value	Units
Peak Capacity	9,200	cfm
Biotrickling Filter Media Empty Bed Retention Time (EBRT)	10	seconds
Biofilter Media Empty Bed Retention Time (EBRT)	20	seconds
Total Design Pressure Drop Across Three Media Beds	Less than or Equal to 6	In WC

The process drawings provided by Biorem show that foul air from the MEB and SRTs are routed directly to the Biorem reactors. Plant effluent is used for recirculation and irrigation systems. Performance testing was later performed as part of the 2009 OCMP Update report.

The SHOC was rebuilt in 2011. After running Beta mode per the Odor Control Master Plan Update recommendation (refer to **Section 2.6**), the support columns of the scrubbers collapsed. After the re-build, MSD changed the media type in Stage 3 to improve reduced sulfur compound (RSC) removal.

2.6 Odor Control Master Plan Update (2009)

To assess the effectiveness of new odor control systems –the BOC biotrickling scrubbers (2007) and SHOC biotrickling scrubbers (2008) – MSD contracted WEA to perform follow-up odor and RSC testing and subsequent investigation via dispersion modelling. A report was submitted summarizing the findings and dated February 2009.

The first round of air sampling was conducted in July 2008, and the second round was conducted in August 2008. Air samples were collected at a total of (26) locations across the Plant. **Table 2-9** summarizes the odor panel testing results for the (5) locations with the highest D/T values.

Table 2-9 Highest Odor and H_2S Sources, OCMP Update 2009

	Top Odor Sources (% of Total Odor Emission Rate)	Top H_2S Sources (% of Total H_2S Emission Rate)
July 2008 Sampling	(1) MEB Dryer Area Roof Exhaust Fans, 40% (2) Annular Space for Digesters, 17% (3) BOC Outlet, 16%	(1) Annular Space for Digesters, 53% (2) MEB Dryer Area Roof Exhaust Fans, 19% (3) MEB Exhaust Plenum,.12%
August 2008 Sampling	(1) MEB Dryer Area Roof Exhaust Fans, 37% (2) BOC Outlet, 15% (3) MEB Exhaust Plenum, 13%	(1) Annular Space for Digesters, 20% (2) Primary Clarifier Effluent Weirs, 19% (3) Plant Influent Channel & Junction Chamber, 14%

Of the (26) air sampling locations, the highest contributor to odor emissions were the MEB Dryer Area Roof Exhaust Fans (40% of total odor emissions in July, 37% in August). Other large odor sources were the Digesters, the BOC Outlet, and the MEB Exhaust Plenum. Results showed that the highest sources of H_2S emissions were the Digesters (53% of total H_2S emissions in July, 20% in August), as well as the MEB Dryer Exhaust Fans and Exhaust Plenum, the Primary Clarifier Effluent Weirs, and the Plant Influent Channel and Junction Chamber.

In addition to air sampling, the following investigations were performed:

- Community odor survey at (11) locations within the communities adjacent to the Plant, including H_2S, odor intensity, odor character, odor source, wind speed, wind direction, ambient temperature, and weather condition observations.
- Liquid sampling from the inlet and outlets of the primary clarifiers, and testing for total sulfides
- Odalog (H_2S) monitoring at the TUS, SRT, SHT, solids blend well, MEB Solids, SHOC Inlet, SHOC outlet, and BOC inlet
- SHOC performance testing
- BOC performance testing
- Supplemental testing on MEB Exhaust Plenum and Dryer Area Roof Exhaust Fans

The performance testing showed that the SHOC biotrickling scrubbers were performing as well as expected, with an average H_2S removal efficiency of 99.94%. During the BOC performance testing, some operational issues impacted the first day of results (September 3rd, 2008). These issues were resolved, and the system was retested on September 4th, 2008. Follow-up testing of the MEB Exhaust Plenum and Dryer Area Roof Exhaust Fans are a consistent daily source of odor emissions, and that odor reduction could be achieved by turning the 6th floor fans off.

Using the odor panel testing results, dispersion modelling was performed for several odor control scenarios. **Table 2-10** shows the peak D/T and frequency results for each of the proposed improvement alternatives at two (2) offsite locations within the community. It should be noted that Models 3 and 4 also include Strobic fans added to screens, grit building, and dumpster room.

Table 2-10 Dispersion Modelling Summary, OCMP Update 2009

Model No.	Model Description	Peak Odor Concentration (D/T)		Odor Event Frequency (#/ yr)	
		Cecil and Fortson	39th and Stratton	Cecil and Fortson	39th and Stratton
1a/1b	Base Conditions Model Round 1 and 2	340	45	140	110
2	Existing Conditions with MEB Improvements	340	20	120	75
3	Existing Conditions with MEB Improvements and Chemical Injection (Hydrogen Peroxide and/or Ferrous Chloride)	100	15	65	50
4	Existing Conditions with MEB Improvements, Odor Control at Headworks and primary clarifiers via BOCs	150	20	60	70

Dispersion modelling results showed major odor reduction improvements with proposed MEB improvements, which included repair of air leaks in Activated Sludge Process (ASP) drying system and replacement of 6th floor roof fans with two new 90,000 cfm propeller fans. In addition, the modelling results showed that the addition of chemicals to the Headworks (Model 3), or the collection and treatment of air from the Headworks and primary clarifiers (Model 4) will both reduce Peak D/Ts in the community by 50% or more and meet MSD's goal of an offline odor level of 20 D/T or less, and less than 100 odor events per year.

This report evaluated several odor control improvement projects in target areas including:

- Control of MEB Building Emissions including operational testing of dryer system, replacement and repair of leaks in ductwork, replacement of existing bucket elevators, replacement of conveyor cover gaskets, and potentially the replacement of existing 6th floor fans with two (2) new 90,000 cfm propeller fans.
- Control of Headworks Emissions either by (1) addition of chemicals during peak loading, or (2) installation of covers on the influent flow splitter box, screen building influent channel and grit tanks/channels, and conveyance to BOCs, as well as installation of Strobic Air fans to improve ventilation.
- Control of Primary Clarifier Emissions which can be achieved through several options including (1) covering primary clarifier surfaces and installation of new 200,000 cfm odor control system at the clarifiers, (2) covering the effluent weirs and effluent channels only and install a 10,000 cfm odor control system, and/or (3) chemical feeding upstream of the Headworks facility.
- Implement BOC Improvements which may involve (1) feeding the plant effluent water instead of City water and nutrients, (2) provide steady source of H_2S to the BOC system, (3) air flow rate reduction, (4) water recirculation all the time, and (5) resolution of issue with first stage spray nozzles.
- Perform SHOC Improvements which may involve one of the following four options: (1) Operating the system in the Beta configuration instead of the Alpha mode, (2) addition of a polishing stage if Option #1 does not provide sufficient improvement, (3) chemical feed such as hydrogen peroxide and hydrogen peroxide catalyst to the sludge upstream of the centrifuge blending well, or (4) turn off the SHOC when inlet loadings exceed design conditions or when off-site odor complaints are received and utilize the existing fume incinerators.

- Repair and maintain Pressure Relief Valves (PRVs) on the digesters
- Perform continuous Odalog monitoring and daily diligence

This report also provided a three-year phased Odor Control Master plan for implementation of recommended improvements including budgetary costs which is outlined on page 66 of the Report.

2.7 Recent Odor Control Improvements

2.7.1 *Headworks Modifications (2018)*

In 2018, the MFWQTC underwent improvements at the West Headworks (referred to as the "old" Headworks) and East Headworks (referred to as the "new" Headworks installed in 1998) which are documented in the Contract No. 15677 record drawings. No odor improvements were included in this project. The project included installation of the following units at each Headworks facility:

West ("Old") Headworks Modifications

- (3) new self-cleaning rake bar screens
- (3) new grit collectors (chain & bucket)
- (2) new screw conveyors (one horizontal, one inclined)
- (2) new belt conveyors (one troughed, one pivoting)
- (186) new Coarse bubble diffusers at Aerated Grit Channel
- (1) New regenerative turbine booster pump

East ("New") Headworks Modifications

- (4) new self-cleaning rake bar screens
- (3) new grit collectors (cyclone and classifier)
- (4) new grit paddle mechanisms with grit slurry piping
- New process drainage piping

2.7.2 *MFWQTC Dryer Replacement*

MSD is currently in the final design phases of the Dryer Replacement Project, MSD Contract No. 16453 which was documented in the 90-percent design set This project included replacement of dryers at the Main Equipment Building, elimination of (4) existing regenerative thermal oxidizers (RTOs) and installation of (2) new RTOs. Major improvements were made to the 6th floor of the Main Equipment Building including replacement of screw conveyors, removal of existing venturi scrubbers and installation of new acid/wet scrubber system and fans. Refer to TM #4 for additional information.

2.8 Ongoing Odor Control Planning

In 2020 MSD contracted Greeley and Hansen to perform detailed field testing and preliminary design of odor control improvements at the primary sedimentation basins and related processes under the Rehabilitation and Replacement of Primary Sedimentation Basins Project (Contract 16460). In September 2020 a complex odor sampling was performed to assess existing odor and RSC emissions. Sampling protocol, odor sampling results, H_2S monitoring results, and additional laboratory results from the October 2020 sampling period were reviewed and summarized in **Section 2.8.1** through **Section 2.8.4.**

Based on the findings of the field sampling, Greeley and Hansen developed a proposed odor control improvements program for the primary sedimentation basins and aerated influent channel. Two (2) recommended odor control alternatives were presented in the "MFWQTC Primary Sedimentation Basin Rehabilitation BODR." The BODR was submitted along with drawings, list of specifications and preliminary cost opinions as part of the 30% design deliverable in September 2020. The 30%submittal documents were reviewed and outlined in **Section 2.8.5**.

2.8.1 *Primary Sedimentation Basin Rehabilitation Odor Sampling Protocol (August 2020)*

Greeley and Hansen submitted a document titled "MFWQTC Primary Sedimentation Basin Rehabilitation Odor Control Sampling Protocol" in August 2020. The purpose of this document was to identify field sampling locations and schedule, as well as procedures, equipment and laboratory analyses to be followed for field testing of the existing Sedimentation Basins and Aerated Influent Channel. **Table 2-11** summarizes the field sampling locations identified by Greeley and Hansen in the August 2020 document.

Table 2-11 Field Sampling Summary, 2020

Sample Location No.	Sampling Location	Time of Day		Sample Method
		AM	PM	
1	Aerated Influent Channel to Sed Basins	Y	Y	Near water surface inside channel
2	Sedimentation Basin No. 1 Inlet	Y	Y	Flux chamber on water surface of basin
3	Sedimentation Basin No. 1 Outlet	Y	Y	Flux chamber on water surface of basin
4	Sedimentation Basin No. 1 Effluent Weir	Y	Y	Flux chamber on water surface of basin
5	Sedimentation Basin No. 4 Inlet	Y	Y	Flux chamber on water surface of basin
6	Sedimentation Basin No. 4 Outlet	Y	Y	Flux chamber on water surface of basin
7	Sedimentation Basin No. 4 Effluent Weir	Y	Y	Flux chamber on water surface of basin
8	Sedimentation Basin Effluent Channel	Y	Y	Flux chamber on water surface of basin

Recommended air sampling methods involved using flux chambers on the water surface, with the exception of Sample Location No. 1, which was taken near the water surface inside the aerated influent channel. It was also recommended that sampling is performed in August 2020 during hot dry days when odors are most prevalent. Tedlar bags were to be utilized for air sampling and properly conditioned prior to sample collection. Tedlar bag samples were to be shipped for testing of VOCs, sulfur compounds, and odor panel testing (See **Section 2.8.2** for odor panel results from St. Croix Sensory, Inc.). This document outlined the protocol for various laboratory analyses using Drager tubes to approximate field concentrations of H2S, methyl mercaptan, and dimethyl sulfide.

2.8.2 *Odor Panel Testing Results (September 2020)*

Air samples from each of the (8) sampling locations were collected on September 30, 2020 and shipped to ALS Environmental and St. Croix Sensory for further testing. Odor panel testing results from St. Croix Sensory were received and evaluated on October 1, 2020.

Reported values included odor concentration (D/T) and recognition threshold (RT) and are presented in **Table 2-12**.

Table 2-12 Odor Panel Testing Results, Sedimentation Basins and Aerated Channel (St. Croix Sensory, September 2020)

Sample Location No.	Sampling Location	AM Sample		PM Sample	
		Odor Conc. (D/T)	Recognition Threshold (RT)	Odor Conc. (D/T)	Recognition Threshold (RT)
1	Aerated Influent Channel to Sed Basins	540,000	340,000	44,000	23,000
2	Sedimentation Basin No. 1 Inlet	180,000	100,000	240,000	130,000
3	Sedimentation Basin No. 1 Outlet	N/A[1]	N/A[1]	96,000	51,000
4	Sedimentation Basin No. 1 Effluent Weir	N/A[1]	N/A[1]	53,000	32,000
5	Sedimentation Basin No. 4 Inlet	140,000	72,000	35,000	22,000
6	Sedimentation Basin No. 4 Outlet	5,900	3,000	46,000	27,000
7	Sedimentation Basin No. 4 Effluent Weir	400,000	210,000	430,0000	230,000
8	Sedimentation Basin Effluent Channel	82,000	42,000	270,000	150,000

[1]Sample bag was received without sample. Hole was located in sample bag.

Across the (8) sampling locations, the AM sample at the Aerated Influent Channel to the Sedimentation basins showed the highest odor concentration (D/T 540,000 and RT 340,000), followed by the PM sample of the Sedimentation Basin No. 4 effluent weir (D/T 430,000 and RT 230,000). The lowest odor concentrations were observed at the Sedimentation Basin No. 4 outlet during the morning hours (D/T 5,000 and RT 3,000) followed by the Sedimentation Basin No. 1 inlet during evening hours (D/T 35,00 and RT 22,000).

2.8.3 *H_2S Monitoring (October 2020)*

H_2S concentrations were continuously monitored from October 1, 2020 to October 8, 2020 at four locations. Available documentation included graphs of H_2S concentrations (ppm), temperature (degrees F), and humidity (%) across the monitoring period. The graphs also included computation of average, minimum and maximum H_2S concentration during the monitoring period. The H_2S monitoring instrument was not indicated in available data. **Table 2-13** summarizes the monitoring locations and associated H_2S characteristics included in the H_2S monitoring documents.

Table 2-13 H_2S Monitoring Results, Sedimentation Basins and Aerated Channel, October 2020

H_2S Monitoring Location No.	H_2S Monitoring Location	H_2S Concentration (ppm)		
		Average	Minimum	Maximum
1	Aerated Influent Channel to Sed Basins	44.0	0	66.0
2	Sedimentation Basin No. 1 Effluent Weir	20.1	0.2	89.2
3	Sedimentation Basin No. 4 Effluent Weir	9.7	0.6	60.3
4	Sedimentation Basin Effluent Channel	0.7	0	4.1

H_2S concentrations were highly variable at the Aerated Influent Channel (Location No. 1) and reached approximately 65 ppm multiple times each day between October 1 to October 8, 2020. Average H_2S levels were also highest at the Aerated Influent Channel at approximately 44.0 ppm. Peak H_2S levels at the Sedimentation Basin Effluent Weirs (Nos. 2 and 3) occurred at approximately 1:00 AM on October 8 (89.2 ppm and 60.3 ppm, respectively). H_2S concentrations were lowest at the Effluent Channel (No. 4), with an average concentration of 0.7 ppm and the peak H2S concentration (4.1 ppm) occurring mid-day on October 3, 2020. Generally, the H_2S concentrations followed the trends of temperature and humidity at each location.

2.8.4 *Additional Laboratory Analyses (September 2020)*

In addition to odor panel testing and H_2S monitoring, MSD contracted ALS Environmental to perform laboratory analysis of (2) of the samples collected on September 30, 2020. The samples were received and analyzed on October 1, 2020. A spreadsheet from ALS Environmental was provided containing the laboratory results at the Aerated Influent Channel and. **Table 2-14** summarizes the compounds detected and associated concentrations for each.

Table 2-14 Laboratory Results Summary (ALS Environmental, September 2020)

Location No.	Sampling Location	Concentration (ppbV)					
		H_2S	Carbon Sulfide	Methyl Mercaptan	Dimethyl Sulfide	Carbon Disulfide	Dimethyl Disulfide
1	Aerated Influent Channel to Sed Basins	280,000	ND	6,100	800	220	170
2	Sedimentation Basin No. 1 Inlet	12,000	ND	3,700	150	ND	5,500
3	Sedimentation Basin No. 1 Outlet	94,000	ND	300	89	ND	ND
4	Sedimentation Basin No. 1 Effluent Weir	99,000	ND	620	130	ND	ND
5	Sedimentation Basin No. 4 Inlet	4,400	ND	1,000	39	ND	320
6	Sedimentation Basin No. 4 Outlet	2,100	28	160	44	20	ND
7	Sedimentation Basin No. 4 Effluent Weir	44,000	ND	270	48	ND	ND
8	Sedimentation Basin Effluent Channel	25,000	ND	200	37	ND	ND
ND = Compound was analyzed for, but not detected above the laboratory reported limit							

As expected, the highest levels of H_2S (280,000 ppbV) and methyl mercaptan (3,700 ppbV) were observed at the Influent Channel. The Sedimentation Basin No. 1 also showed relatively high levels of sulfur compounds. Generally, Sedimentation basin No. 1 showed higher concentrations of sulfur compounds compared to Basin No. 2. According to the laboratory results in **Table 2-14**, the sedimentation basins reduced H_2S levels by 91%, methyl mercaptan by 97%, and methyl sulfide by 95%.

2.8.5 *MFWQTC Primary Sedimentation Basin Rehabilitation BODR (September 2020)*

The "MFWQTC Primary Sedimentation Basin BODR" was submitted by Greeley and Hansen in September 2020 to document the scope of work and design criteria for the Replacement and Rehabilitation of Primary Sedimentation Basins and Related Equipment Project. This project is currently ongoing and involves the following components:

- Existing Aerated Influent Channel modifications
- Existing Primary Sedimentation Basins modifications
- Existing South and North Pump Stations modifications
- New CEPT System
- Addition of Odor Control at the Primary Sedimentation Basins and related equipment

The BODR was reviewed to assess the proposed installation of an odor collection and treatment system at the primary sedimentation basins and related equipment. Two (2) alternatives for treatment of primary sedimentation basin odorous air were presented in the report:

Alternative 1: Repurpose the existing BOC System (Bioway) located adjacent to the Bioroughing Towers (refer to **Section 2.4**)

Alternative 2: Construct a new odor control system using new Biotrickling Scrubbers

Regardless of the selected alternative, the proposed odor control system will consist of the following:

- 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 2-15 presents the preliminary basis of design for the proposed odor control systems included in Alternative 1 and Alternative 2 of the BODR.

Table 2-15 Primary 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 Concentration	30 ppmv (avg)/ 2000 ppmv (peak)	60 ppmv (avg)/ 150 ppmv (peak)

The report indicates that the biotrickling scrubbers (Alternative 1) was the recommended odor control strategy based on MSD's experience with the BOCs, anticipated odor compounds and concentrations and lower O&M requirements compared to other methods, and proven efficacy.

3. Conclusions and Recommendations

3.1 Conclusions

Review and evaluation of available documents were performed to understand existing and future odor control systems at MFWQTC and aid in identifying process areas for further evaluation as part of the OCMP Update. Based on the findings of the background document review and discussions with MSD staff, updated process flow diagrams were developed to summarize existing and future odor control systems at MFWQTC. These diagrams capture the existing odor control systems as well as the two (2) future odor control system alternatives presented in the 2020 Sedimentation Basin Rehabilitation BODR.

Major improvements have been made to the odor control systems at the SRTs and MEB. The original fume incinerators were replaced in 2006 with the SHOC biotrickling scrubbers by Biorem, and rebuilt in 2011. Performance testing from 2008 showed that the biotrickling scrubbers were performing well, although some outlet H_2S spikes were observed during peak loading. The 2009 OCMP Update outlined several operational modifications which could be implemented to improve existing odor control system performance. Under the Dryer Replacement project (Contract No. 16453), a new dryer system, RTOs, fugitive dust wet scrubber, polycyclone, main fan, venturi scrubber fan, acid scrubber, wet scrubber, and pellet coolers were installed at the MEB to treat foul air streams and fugitive air dust.

MSD plans on implementing odor collection and treatment processes at the Sedimentation Basins and Aerated Influent Channel in the near-term. In September 2020, detailed air sampling (odor concentrations and reduced sulfur compounds) and H_2S monitoring were conducted at target areas within the Sedimentation Basins and the Aerated Influent Channel. Two (2) future odor control alternatives were presented in the BODR which involve re-purposing the existing BOCs or installing a new odor control system.

It should also be noted that MSD does not currently perform ferric chloride dosing at MFWQTC. In addition, the existing Headworks process units are not equipped with an odor control system.

3.2 Recommendations

The OCMP Update will involve a multi-step approach to develop recommended odor control improvements at MFWQTC. Detailed field sampling will be performed at target locations to assess existing odor conditions. Using sampling results, dispersion modelling will be performed to evaluate potential odor control scenarios.

Sampling

Available sampling and performance testing data were reviewed to identify process areas at the MFWQTC which should be included in the OCMP Update sampling program. The following two (2) process areas were identified as key sampling locations:

1. **Headworks (East and West):** Typically, in Headworks design projects or Headworks upgrade projects, all influent and bar screen channels as well as grit system units and channels are completely covered. The foul air under these covers at the Headworks is then exhausted to a dedicated odor control system. Headworks odor control systems are common design practice since they serve two purposes: to provide a safe atmosphere for plant operators entering the Headworks in order to perform routine maintenance as well as minimizing odors to the

surrounding community. This odor control system for the East and West Headworks will be evaluated further in TM #5. Sampling has not been conducted at the Headworks since 2001 and therefore is considered a critical sampling location for the OCMP Update.

2. **SHOC Biotrickling Scrubbers:** Detailed sampling has not been performed at the existing Biorem biotrickling scrubbers since the 2009. The proposed OCMP Update sampling program will include a complex sampling program at the SHOC system to assess its current odor removal efficiency and if additional treatment units will be required.

3. **Digesters**: Detailed sampling has not been performed at the digesters since 2009.

Specifically, updated odor panel testing, H_2S monitoring, and sulfur compound testing is recommended at the process areas listed below. Ranking of sampling locations will be evaluated based on available documentation and will be provided in future reports.

- Aerated Grit Channels
- Plant Influent Channel and Junction Chamber
- West Headworks Room Exhausts
- East Headworks Room Exhausts
- Digesters
- Sludge Holding Tanks
- DAFT Exhaust

Air flow, odor, sulfur compound, H_2S, ammonia sampling and performance testing should have been conducted at the MEB after completion of the Dryer Replacement Project. Sampling results including inlet and outlet loading rates shall be provided for the following equipment:

- New RTOs
- New dryer system
- New wet scrubber
- New fugitive dust wet scrubber

In addition, the contractor selected for the ongoing Sedimentation Rehabilitation and Replacement of Related Equipment Project shall perform follow-up testing on the future odor control system serving the sedimentation basins and aerated influent channel. Inlet and outlet loading conditions and sampling results at the new odor control system should also be provided from the contractor for inclusion in the OCMP Update. Depending on follow-up testing at the odor control systems installed at the MEB and Sedimentation Basins, these odor control systems may need to be re-assessed a part of the new OCMP.

OCMP Update Goal

Current and future odor control projects shall achieve 20 D/T at surrounding receptors. It is recommended that at least one (1) receptor is used in each wind direction for the dispersion modelling task.