

Technical Memorandum

To: Bryan Foster
City of Manassas
Manassas, VA 20110

Date: January 18, 2019

Subject: Micron Pond Odor Evaluation

1. Introduction

Kimley-Horn and Associates, Inc. (Kimley-Horn) was contracted to perform an evaluation of odor concerns associated with the Micron Pond for the City of Manassas (City). The Micron Pond is owned and maintained by the City. The 100 million-gallon holding pond (covering approximately 16 acres) stores industrial wastewater effluent from the nearby Micron Technology, Inc. (Micron) facility. The Micron facility generates an industrial wastewater pretreated at the Micron facility to meet industrial discharge standards. Micron has a permit limit to discharge up to 2.5 million gallons per day (MGD). Historically, the City has received complaints from nearby residents regarding odor believed to be coming from the pond or associated with the pond discharge into the City's wastewater collection system. The purpose of this evaluation is to consolidate available information, obtain additional data to identify the potential sources of the odor concerns, and establish a remedy plan to mitigate the odor concerns.

The City typically directs the Micron effluent into its gravity sewer interceptor, which conveys the flow to the Winter's Branch Pump Station (WBPS) operated by the Upper Occoquan Service Authority (UOSA). The City has capacity limitations for the quantity of wastewater it discharges to UOSA based on a 30-day rolling average. During peak flow conditions in the City's sewer network, the City diverts Micron's discharge to the holding pond (Micron Pond) to equalize flows and stay within allowed UOSA capacity limits. The effluent within the pond can either discharge by gravity to the City's interceptor or be pumped directly to the WBPS. An overview of the system is shown in Figure 1.

According to City staff, a majority of the odor complaints have been received while the pond was in use (i.e., during filling, holding, or draining). The general perception is the odors have a "rotten egg smell." Testing completed by the City indicated the presence of hydrogen sulfide gas with the odors. This evaluation was performed to discover the root cause of the odor generation as well as investigate means of odor minimization.

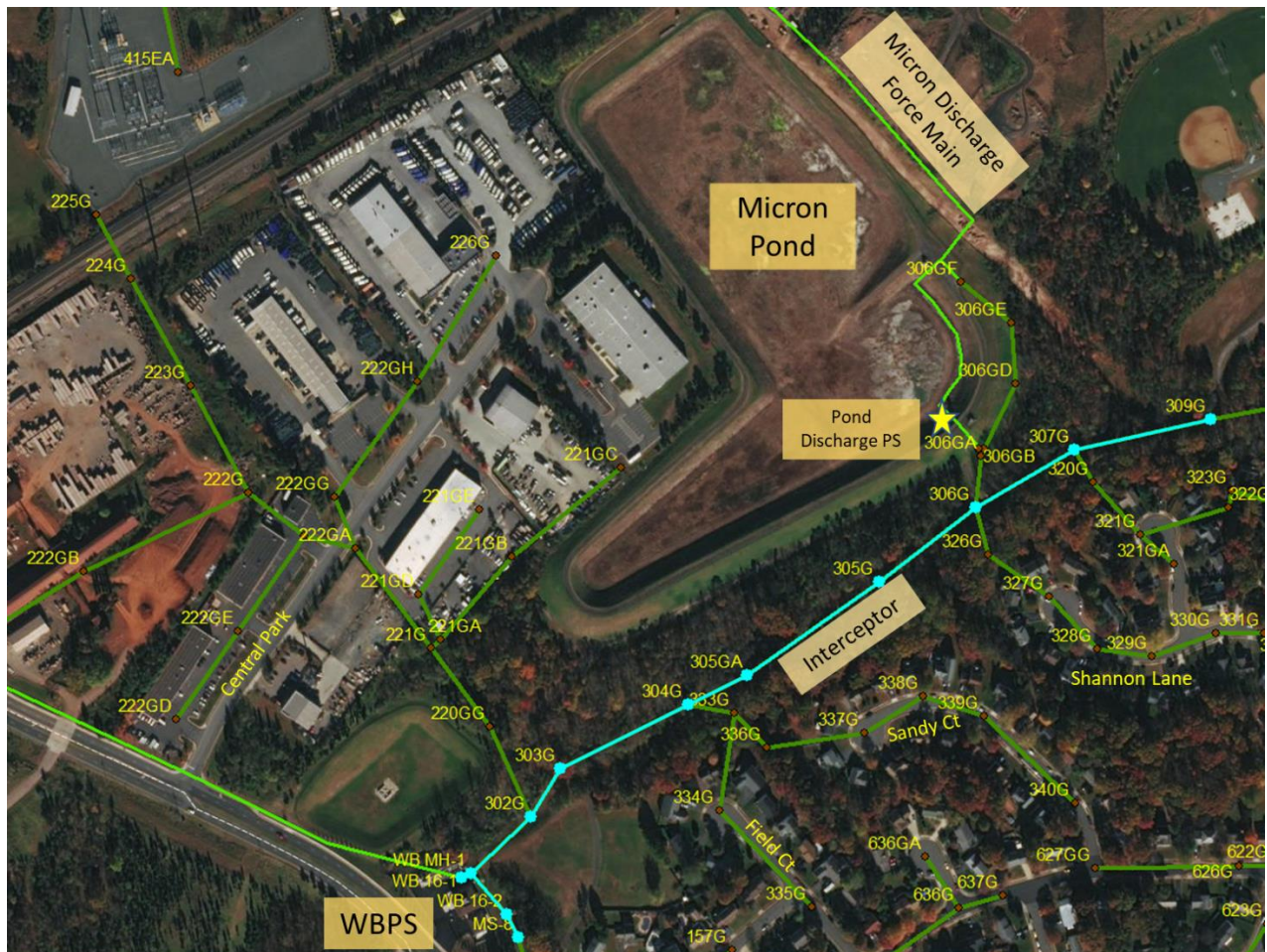


Figure 1 Study Area

2. Background

A. Sewer System

Micron generates industrial wastewater from its manufacturing process. Micron has an industrial pretreatment discharge permit and pretreats its wastewater onsite prior to discharge to the City’s system. Site inspection of Micron’s pretreatment facility identified a chemical stabilization process to neutralize the effluent (i.e., adjust pH) prior to discharge. Micron can temporarily divert its wastewater to holding tanks onsite if further treatment is required prior to discharge. A sample of Micron’s pumping discharge rate data (recorded every 5 minutes) shows variation from zero to greater than 3.5 MGD (see Figure 2).

According to City officials, Micron discharges an average of 2.3 MGD. With Micron’s next plant expansion, an additional average daily flow of 1.3 MGD is anticipated (total of 3.6 MGD). Following that expansion, three other expansion phases could occur with each phase potentially adding 1.3 MGD average daily flow (for a total of 7.5 MGD from Micron). The City is currently increasing its capacity allocation with UOSA; however, the allowed UOSA capacity versus the increased flows from Micron can affect the City’s intended length or frequency of use of the Micron pond

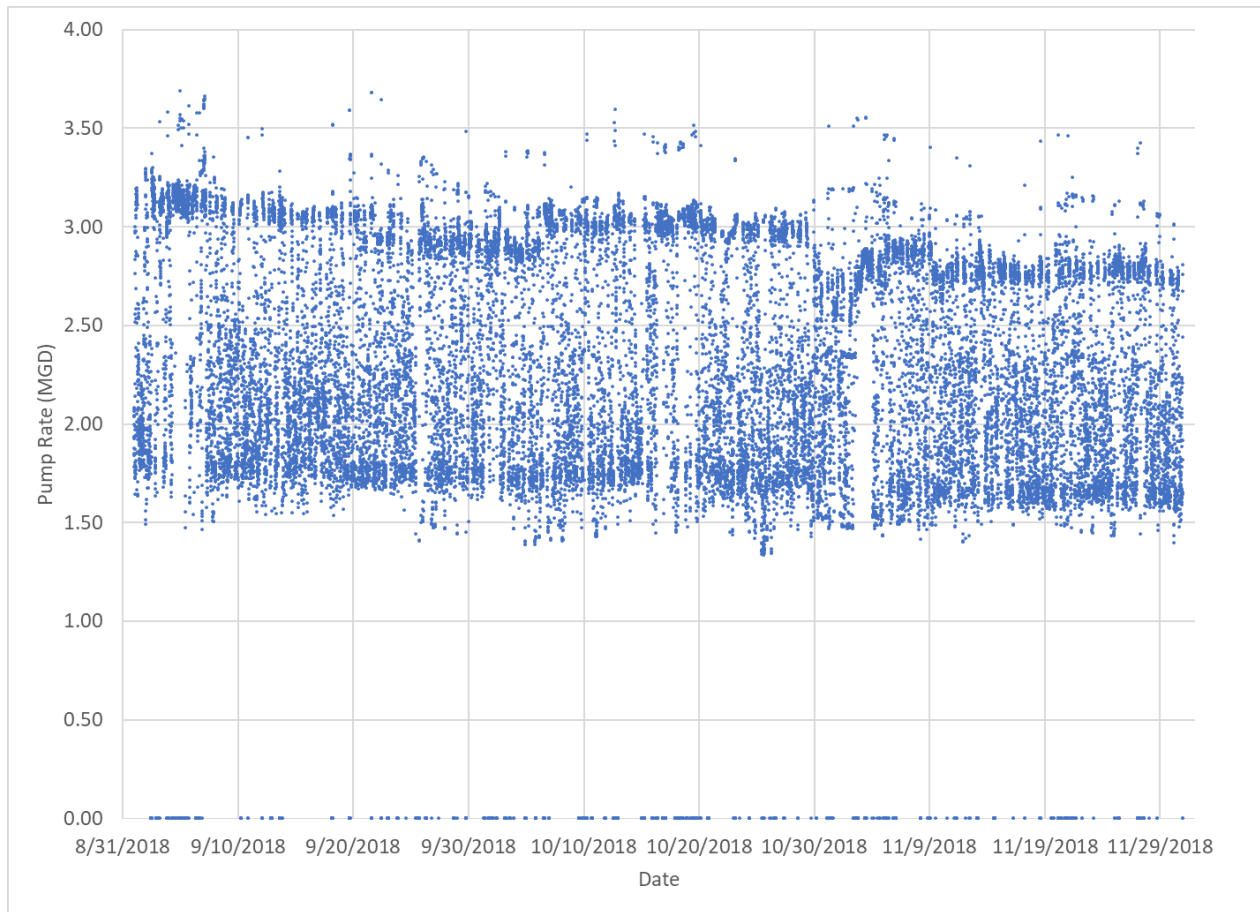


Figure 2 Micron Discharge Rate

Micron pumps its industrial wastewater through 3,500 linear feet of 18” diameter force main plus 1,140 LF of 12” force main to the point of discharge near the pond to a City sewer. The effluent flows to the City’s interceptor unless the City diverts the discharge to the Micron pond. The City installed a system to add a proprietary odor control chemical, Bioxide®, to the wastewater prior to discharge into the pond near MH 306GF. The Micron wastewater enters the pond by cascading down a step aeration structure, which helps mix the Bioxide® in the wastewater.

The Micron pond can be drained by gravity to the City’s interceptor or pumped directly to the WBPS. Just prior to the connection point with the City’s interceptor, the City recently installed a unit to treat odors in the effluent from either Micron’s force main or from the pond’s gravity discharge. The WBPS also has an odor control system.

B. Hydrogen Sulfide

Sulfides refer to any species containing the sulfide ion, one of which is hydrogen sulfide. Hydrogen sulfide occurs naturally, can be manufactured, or can be a byproduct of some industrial processes. It is a gas that can exist in a dissolved state and is responsible for the “rotten-egg” odor in many wastewaters. In

aqueous environments below pH of 7, sulfides exist in a majority form as hydrogen sulfide. Increasing the pH decreases the concentration of hydrogen sulfide such that at pH of 8, only 10% of sulfides are in the form of hydrogen sulfide.

Hydrogen sulfide can be generated by the microbial decomposition of organic matter containing sulfur or from the reduction of sulfites and sulfates. It is not formed in the presence of an abundant supply of oxygen. Conditions where sulfates are present with low levels of oxygen are referred to as anoxic conditions. Examples of these conditions can be found at the bottom of stagnant ponds with decaying vegetation (a source of organic material containing the necessary microbiology) or basins and pipelines carrying wastewater containing sulfates. Bacteria responsible for this process are naturally found in the environment. In an environment such as the Micron pond, layers of decaying vegetation can be a source of bacteria.

Per the Occupational Safety and Health Administration, the odor threshold for hydrogen sulfide is 0.01 to 1.5 mg/L and becomes “more offensive” at 3 to 5 mg/L (www.osha.gov/SLTC/hydrogensulfide/hazards.html).

3. Data Collection

A. Site Investigation

Representatives from the City and Kimley-Horn completed site visits of the Micron pond when it was initially filling in August 2018 and when it was holding wastewater in September 2018 (neither filling nor draining). No rotten egg odor was evident at either of these visits; however, City staff noted that before the September 2018 visit, a strong odor was evident. As a result, the City acted to address the odor with the installation of 10 pond aerators. The City had not previously used pond aerators.

City staff indicated it has maintained the pond by scraping the bottom to bedrock at least once a year. However, historically there has been vegetative growth in the Micron pond. During the August 2018 site visit, vegetation was observed growing in the pond as it was being filled (Figure 3).

In September 2018, several manholes downstream of the Micron discharge location along the City’s interceptor and at the WBPS were opened and observed. At that time, no significant odors were noted. The inspection revealed the wastewater level in some manholes along the City’s interceptor and at the WBPS was above the crown of the interceptor pipe (referred to as a surcharged condition). At that time, a recently installed City-odor control system immediately downhill from the Micron pond was not yet activated.



Kimley-Horn visited the UOSA WBPS in September 2018. During the visit, the manhole shown as WB MH-1 on Figure 1 (the first manhole upstream of the pump station) was surcharged. No other facilities within the pump station itself were surcharged as sewage passed through the station. The station includes a ventilation system and an activated carbon odor control system to collect and treat odors from sewer gases collecting within the pump station.

Subsequent discussions with City of Manassas staff revealed odor issues and complaints have historically been associated with the use of the Micron pond, although some odor complaints may have been received independent of the pond. City staff verified odor complaints and staff recognition of odors are not typical when the pond is not used and Micron discharges directly to the City interceptor.

B. Sampling Data

The City of Manassas provided historical data related to Micron discharge and the pond discharge. Some of the data provided was associated with the period when the City utilized the Micron pond in 2014. At that time, hydrogen sulfide gas monitors and data loggers were installed in four sanitary sewer manholes (MH 305G, 306G, 333G and 337G). Installation details were not available, but the loggers recorded significant levels of hydrogen sulfide gas (Attachment 1.A). Discussions with City staff also noted significant odors emanating from the pond itself. Notes associated with the detection of hydrogen sulfide indicate the gas was present when the Micron pond was being drained and manholes along the City interceptor downstream were at times surcharged (Manhole 305G and at the WBPS). It should be noted that during this time the interceptor was in a surcharged condition upstream of the WBPS, which can allow lower concentration gasses in the upstream sections of pipe to accumulate and concentrate the hydrogen sulfide levels. The data loggers recorded high levels of hydrogen sulfide during this time supporting this theory.

In August and September 2018, City staff completed 2 weeks of Micron discharge sampling. Sulfide sampling was not part of the analysis. However, staff recorded pH, temperature, H₂O₂, turbidity, and some general observations. In all 14 samples, pH was between 7.14 and 8.46. During two events, the staff had to wait for Micron flow to begin to collect the sample. Once flow began, strong hydrogen sulfide odors were noted (refer to notes provided in Attachment 1.B). On two additional occasions, wastewater was flowing at the time of sampling and there were some sulfidic odors noted (it is not known whether flows had stopped prior to sampling).

Sampling results provided by Micron for permit compliance showed evidence of high levels of sulfates and recently provided pH data from Micron recorded a range from 6.25 to 8.6. The majority of pH results were above 7.0 (Figure 4).

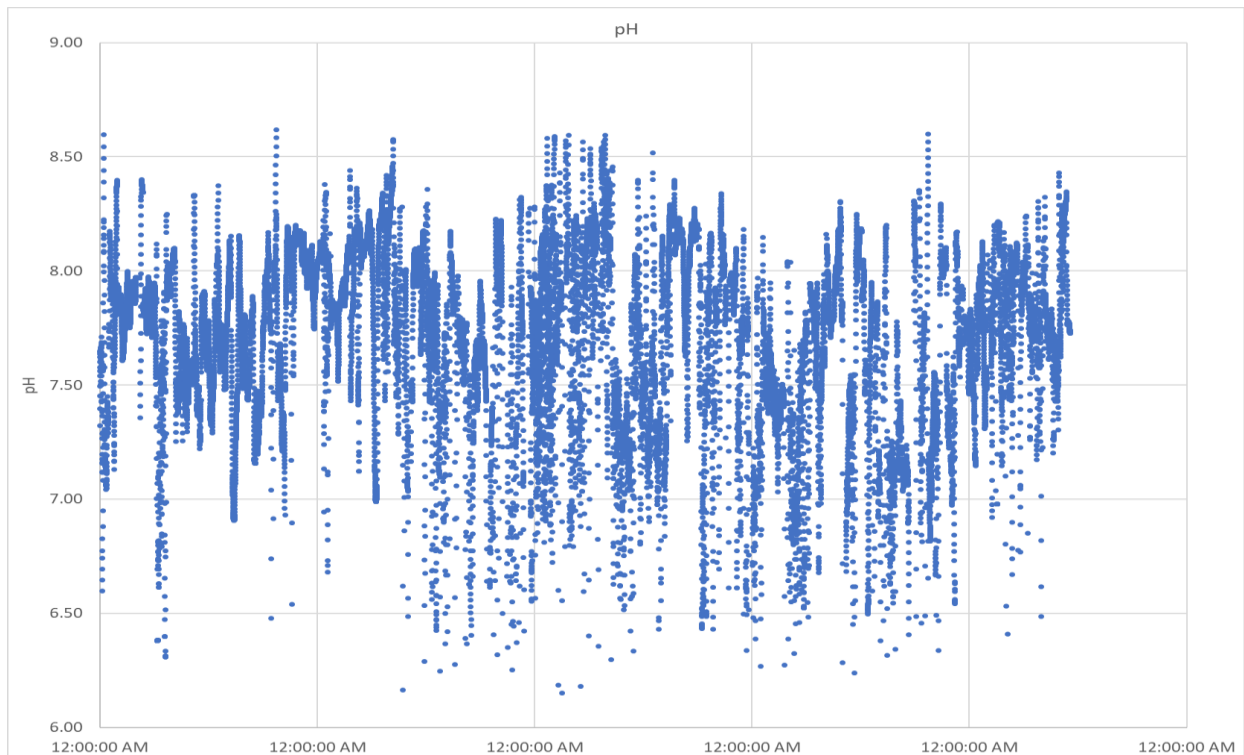


Figure 4 Micron pH Data

Micron conducted testing of its discharge for sulfides. Sulfide sampling of the effluent at the Micron facility showed results non-detectable to 0.1 mg/L (Attachment 1.C). The City conducted daily sampling for sulfides for one week at the point of discharge into the City’s sewer system near the pond (MH 306GF). During this testing, there were no detectable total sulfides (to a method detection limit of 0.4 mg/L). Testing results are provided in Attachment 1.D.

Samples were also collected just upstream and downstream of the confluence of the Micron discharge with the City wastewater flow in the gravity collection system (MH 309G and MH 304G, respectively). During this specific testing, no sulfides were reported (to a method detection limit of 0.4 mg/L).

All testing completed by the City for sulfides and pH was conducted when the Micron effluent was actively flowing into the City sewer system. All pH testing completed by the City resulted in pH above 7.0 with most above 8.0.

C. Sewer System Hydraulic Data

The sewer system from the Micron discharge location to the WBPS was investigated to understand system hydraulic conditions. Sanitary sewer systems are designed to limit the effects of potential odors contained within. Typically, gases move downstream with the direction of flow to an outlet location (such as at a pump station). If a sewer outlet is submerged or a gravity pipeline flows completely full (i.e., is surcharged), gases and odors will not be conveyed to the intended outlet.¹ Hydraulic conditions of the

¹ *Wastewater Engineering, Collection and Pumping of Wastewater*, Metcalf and Eddy, 1986

gravity interceptor were reviewed to evaluate the possibility of surcharged conditions. This analysis is based on flow monitoring as well as sewer invert elevations and sizes provided by the City. City staff noted the sewer invert elevations were collected in house and might not reflect survey-quality accuracy.

Between October 11 and November 9, 2018, the City of Manassas conducted flow monitoring along its interceptor at three locations: Manhole 309G (upstream of where Micron discharge enters), Manhole 305G (downstream of the Micron discharge), and Manhole 162 (WB 16-2 per Figure 1). Graphical representation of the metered flows and daily statistics with associated rainfall are presented in Attachment 1.E.

Metering data was reviewed to verify how Micron flow rates vary. The difference in flow rates between the Manhole 309G and 305G approximates the flows from the Micron facility (some residential flows from Field Court, Sandy Court, and part of Shannon Lane are included in this difference). A sample of the resulting flows during the monitoring period are shown in Figure 5 and are consistent with flow metering data provided by Micron. Based on this data, flows stopped for periods of up to 3 hours several times a day (shown where flows drop to around 0.2 MGD) with no discernable pattern. When Micron was discharging, instantaneous rates varied from approximately 1.3 MGD (900 gpm) to 3.2 MGD (2,220 gpm).

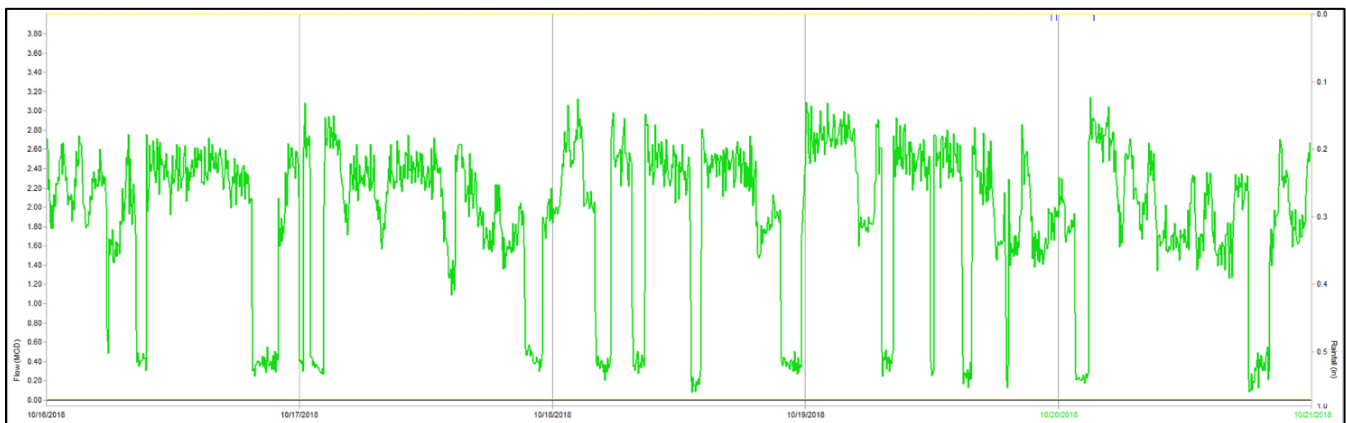


Figure 5 Approximate Micron Flows (MGD)

Based on discussions with Micron, Micron cannot predict the timing or duration of when pumping to the City is stopped. Flows are diverted to onsite holding tanks for further treatment only if a permit violation could result. Once the effluent is appropriately treated, Micron resumes pumping. Discussions with City staff have indicated significant odors primarily when pumping resumes; however, sampling has not confirmed the presence or intensity of odors.

Statistics from metering of City flow rates with Micron flow data are presented in Table 1. Micron’s future expansions assume an increase of 1.3 MGD per phase with up to 4 phases for a possible 5.2 MGD additional flow. Per the City, this evaluation considers only the first phase of Micron’s expansion in future flows. In this scenario, Micron flow would total an average of 3.6 MGD.

Table 1 Current and Future Flows

Location	Current (MGD)		
	Minimum	Average	Peak
Upstream of Micron Flows (309G)	0.30	0.7	1.8
Downstream of Micron Flows (305G)	0.3	2.6	4.5
Micron (per Micron data)	1.3	2.3	3.2
From southeast to WBPS (162-A)	0.5	1.5	3.8

The current ranges stated in the table above just consider flows observed during the monitoring period from October 11, 2018 to November 9, 2018. A typical design flow is the product of a peak factor (a 3.0 to 4.0 peak factor is often used) and the calculated average daily flow, which may vary from the monitored average daily flow. In addition, actual peak flows may vary because of rainfall derived inflow and infiltration (RDII) and other factors. Finally, the City’s buildout flows to the interceptor sewer from the City’s customers were not calculated as part of this evaluation; however, City staff anticipates no significant changes for buildout conditions.

A model of the local sewer system was developed using EPA SWMM v 5.1 to evaluate conditions in the City’s interceptor sewer to the WBPS. The system configuration was developed from survey provided by the City (the survey configuration does not match the City’s GIS shown in Figure 1). The modeled system schematic is presented in Figure 6. Key manholes are highlighted in the model structure and are noted as follows:

- 306G: Micron flow into the City interceptor where another neighborhood trunk line enters
- 304G: Neighborhood trunk line enters
- 302G: Trunk line from the Central Park drive commercial complex enters

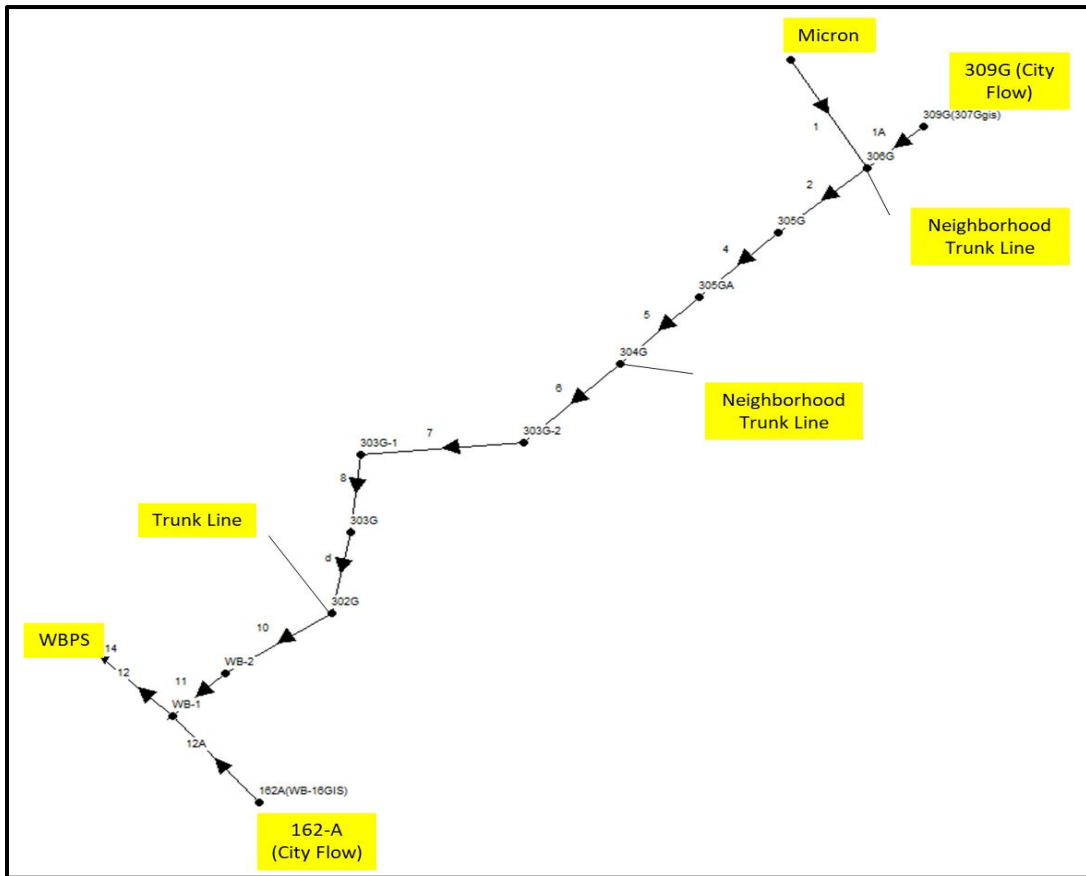


Figure 6 SWMM Model Configuration

Various combinations of flows as described below were input into the model to include flows from Micron, flows from 309G, and 162-A per the City’s flow metering data. The results are shown in the graphics that follow. The graphics show the sewer system profile with the modeled water depth shown in cyan. If the sewer surcharges in the model, the dark blue line represents the surcharge level.

Combinations of flow as taken from the table of flows above were modeled (for existing conditions) to represent minimum (Figure 7), average (Figure 8), and peak flow (Figure 9) conditions. In all cases, except the minimum flow conditions (with Micron flow at 1.3 MGD), the City interceptor receiving flows from Micron surcharged at the manhole just upstream of 304G. The figures clearly depict the reverse slope in the sewer between Manholes 304G and 305GA as identified by the survey provided by the City (Manhole 304G receives flow from Sandy Court and Field Court residences). Additionally, a flat or reverse slope can be observed in the existing sanitary sewer near the WBPS.

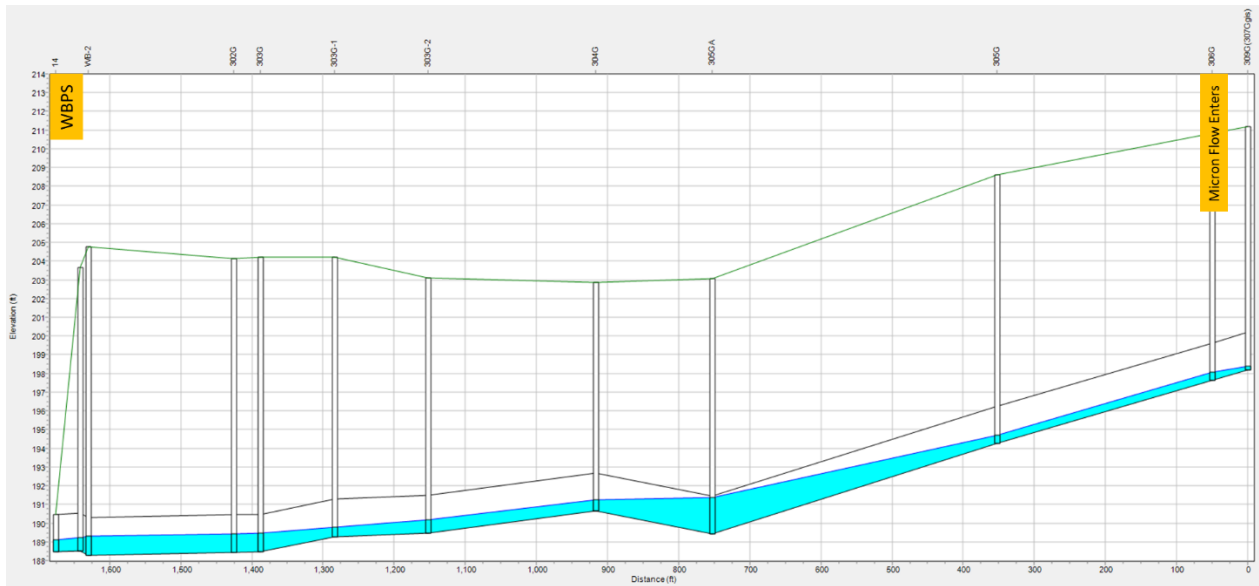


Figure 7 Minimum Flow Conditions (Micron at 1.5 MGD)

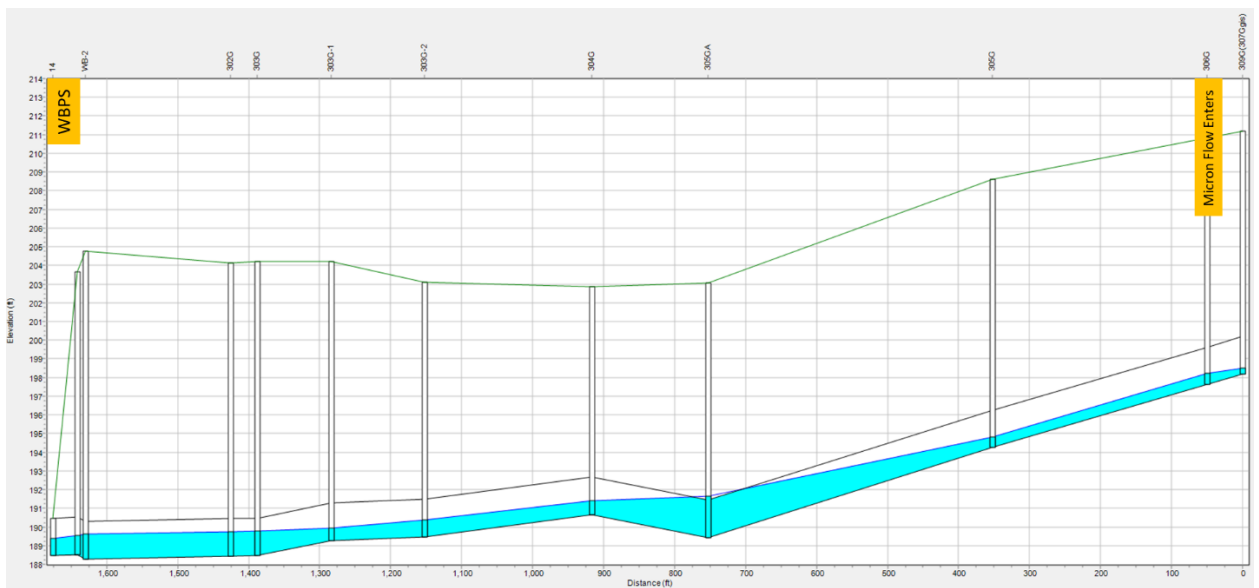


Figure 8 Average Flow Condition (Micron at 2.3 MGD)

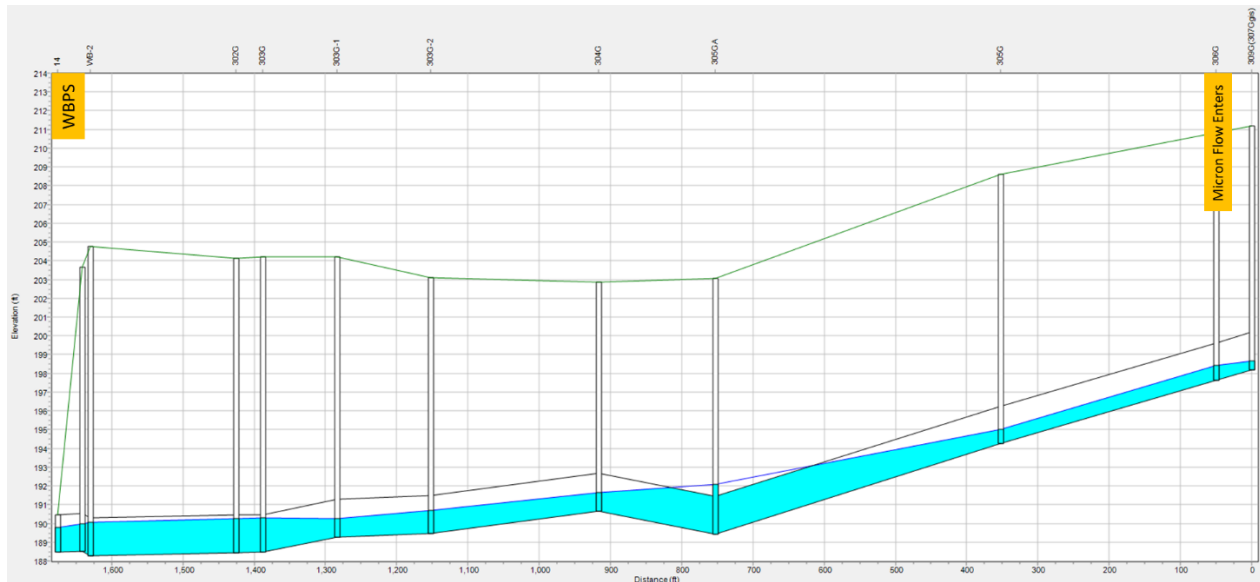


Figure 9 Peak Flow Conditions (Micron at 3.2 MGD)

D. Analysis

From sampling data provided by the City when odors were noted in 2014, hydrogen sulfide gas was detected in significant concentrations in the sanitary sewer system downstream of the Micron industrial wastewater discharge during pond draining operations. City staff also noted odors emanating from the pond itself. During pond use in 2018, odors were noted from the pond prior to the installation of aerators. No “rotten egg” odors were noted at the time of a site inspection when 1) aerators were in use in the pond and 2) Micron industrial wastewater was being discharged directly to the City’s interceptor (bypassing the pond). City staff noted odor complaints and staff recognition of odors may have occurred, but are not typical, when the pond is not used and Micron discharges directly to the City sewer interceptor.

Observations by City staff have noted a “rotten egg” odor from the Micron industrial wastewater discharge when Micron’s pumping resumes following periods of downtime. Odors were not typically noted during continuous pumping periods.

The evidence noted above supports the odors are primarily from hydrogen sulfide. However, based on the sampling of Micron’s industrial wastewater, there is no evidence sulfides are a product of the manufacturing process. Additionally, sampling of wastewater upstream and downstream of the point of Micron’s discharge to the City’s interceptor identified no reportable concentrations of sulfides when Micron wastewater is discharging from the plant directly to the interceptor (i.e., bypassing the Micron pond).

The data collected to date suggests the source of sulfides are likely generated from the conversion of sulfates noted in Micron’s wastewater through anoxic biological processes potentially associated with two scenarios:

1. Anoxic conditions in the Micron pond during prolonged periods of use when available oxygen is first “used up”. Bacteria from either decaying vegetative growth within the pond or otherwise entering the wastewater from the environment convert the sulfates to sulfides. Sulfides would typically be generated in the lower levels of the water column where oxygen from the water surface is not available.
2. Anoxic conditions in the Micron discharge force main primarily associated with periods when Micron stops pumping. These periods may provide adequate time for bacteria present in a layer within the pipe to generate sulfides.

Once sulfides are generated within the wastewater, it can be released from solution and create an odor. This release can be from the surface of the pond water itself or as the pond is drained. Draining wastewater from the lower levels of the pond to the City’s gravity interceptor will release water with the highest concentrations of sulfides.

While there is no evidence to indicate the interceptor system and WBPS are a source of hydrogen sulfide formation, the gas created as described above can be released from turbulence in the wastewater interceptor system. Surcharging within the gravity system will prevent the gas from reaching the WBPS where it can be treated. The recently installed City odor control unit immediately downstream of the Micron pond will help treat odors; however, additional sulfide gas could be released further downstream. Pumping the Micron pond wastewater directly to the UOSA WBPS avoids the release of odors in the City’s interceptor.

Except in special circumstances, gravity sewers are not designed to operate in a surcharged condition. In typical gravity system design, such as the City interceptor receiving Micron flow, surcharged conditions could indicate inadequate capacity. Proper design of sewer systems require venting as sewer gasses are pulled along a pipeline in the direction of flow. In designs where surcharging is acceptable (such as in a siphon), special venting is required. An unintended surcharged sewer prevents the proper movement of gases through the system. Without proper venting, gasses could be released through holes in manholes or other avenues including house roof vents resulting in odors along the interceptor system and at the WBPS.

Hydraulic analysis of the City’s interceptor confirms surcharging occurs within the gravity system. In addition to preventing the proper ventilation of gases in the system and exacerbating the odor issue, it is also indicative of inadequate capacity. Capacity improvements in the interceptor or diversion of Micron flows around the sewer should be considered. Analysis using the sanitary sewer model shows that removal of the Micron flows from the City’s interceptor result in a full pipe flow condition during peak flow periods (as determined from the City’s flow monitoring and shown in Figure 10).

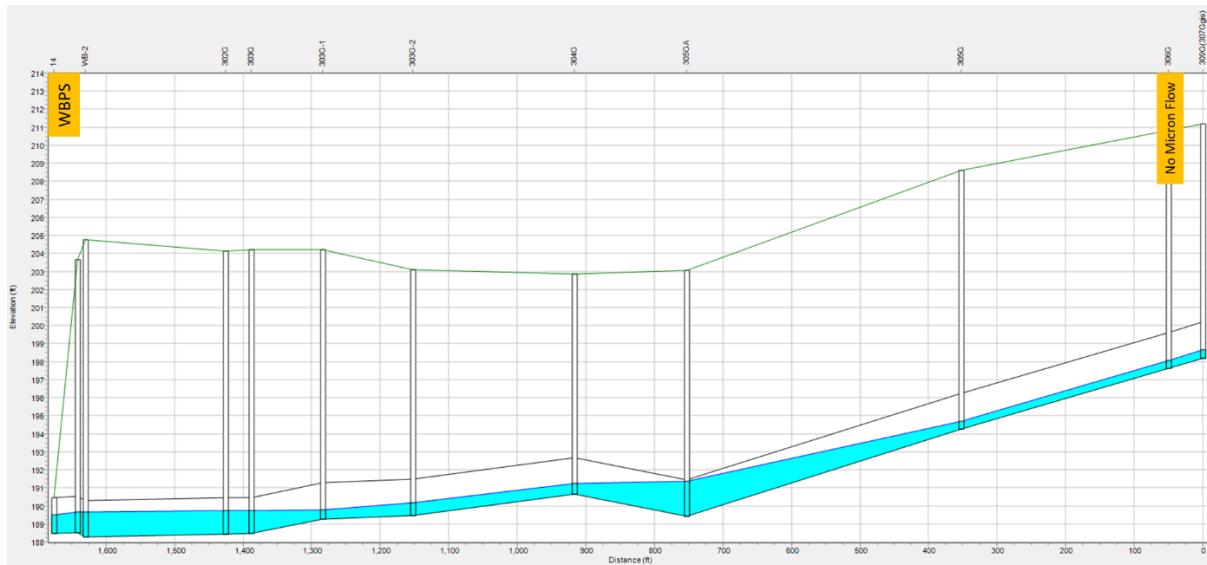


Figure 10 Peak Flow, Zero Micron Flow

4. Conclusions / Recommendations

A. Micron Pond

Addressing sulfide formation within the Micron pond may be achieved by limiting microbial presence within the pond and preventing anoxic conditions from developing when the pond is in use.

The City has initiated installing a reinforced polyethylene liner for the Micron pond. The addition of a pond liner will reduce the potential for vegetative growth and decay in the pond and therefore limit the presence of bacteria responsible for the potential conversion of sulfates to sulfides. The lined bottom of the pond will still require routine maintenance to remove wind-blown dirt and debris to prevent accumulation and the potential buildup of bedding material for vegetative growth.

Alternatives to enhance circulation within the pond during filling and draining operations as well as to enhance future maintenance activities should be considered. Enhancing circulation will reduce the potential creation of stagnant water in the pond that could result in rapid anoxic zone formation. Maintenance enhancements include installing concrete drainage swales to help washdown and sump locations to collect and remove any accumulated solids.

Installing aeration systems within the pond can prevent formation of anoxic zones where sulfides are generated. It should be noted that aeration will only be effective in preventing sulfide formation; if sulfides are already present, aeration is not effective and may release aqueous sulfides into gaseous form. Based on the review of the potential holding time and hydrogen sulfide formation in the pond, the City purchased and installed 10 aerators to improve the amount of dissolved oxygen (DO) in the pond. As a general rule, 115 to 225 gpm of recirculation is required per acre of pond for aeration. The Micron pond is 16 acres, which equates to an overall rate of 1,800 to 3,600 gpm based on a full aeration time of 24 to 48 hours. Specifications for all of the City’s aerators were not available to evaluate.

Surface aerators will sufficiently aerate only to up to 10 feet deep. The Micron pond has a maximum depth of 16 feet for the full 100 million gallons of storage. The surface aerators will prevent stratification for the first 62 million gallons of storage. To aerate the full 100 million gallons, additional submerged mixing or aeration will need to be added to the pond. Aeration should be reviewed and selected based on the intended frequency and depth of use of the pond.

B. Micron Force Main Discharge

The extent of sulfides generated from sulfate conversion within the Micron force main is not known. The degree to which odors are generated from within the force main will determine available options to address the issue. Options could include allowing the newly installed City odor control unit to control odors, divert the flow directly to the WBPS, or pretreat the effluent at Micron. Prior to investigating options, Kimley-Horn recommends installing gas detection units to verify the extent of this concern. Units should be installed at the point of the Micron force main discharge as well as at the newly installed City odor control system. Hydrogen sulfide data should be correlated with Micron force main discharge rates.

C. City Interceptor Sewer

While the City's downstream interceptor does not appear to be a source of hydrogen sulfide gas formation, the system hydraulics may prevent any odors generated from moving downstream where they can be treated. To evaluate alternatives to address potential issues with the interceptor, survey-grade invert and rim elevations of the interceptor are required. Alternatives such as diverting all Micron flows off of the City's interceptor directly to the WBPS (via an independent gravity line, extended force main, etc.), increasing the capacity of the City's interceptor, or routine use of the pond for equalization with pumped discharge to WBPS by the City's pump station may be considered. Each alternative will require coordinating with the City's ultimate wet weather and buildout needs as well as maximum flexibility to accommodate future Micron flows.

Consideration of these alternatives is dependent on the anticipated frequency of pond use. Frequency of pond use is in turn dependent on how carefully City may need to restrict discharge to UOSA depending on if the City is approaching its UOSA capacity limit.

5. Summary

This analysis provides strong evidence the most significant odors associated with study area are from hydrogen sulfide generated after discharge from Micron into the Micron pond. Some odors may also be generated from within the Micron force main, during periods when Micron temporarily stops pumping. The City has recently completed some initiatives to help mitigate the odor issues including installing an odor control system downstream of the Micron discharge location and extending a force main to pump the Micron pond discharge directly to the UOSA WBPS. Initial recommendations for further evaluation and implementation are as follows:

1. Implement pond lining and consider relocating the force main discharge to the north end of the pond
2. Install properly designed aeration devices; including number of surface aerators and deep water aeration for water depth greater than 10 feet

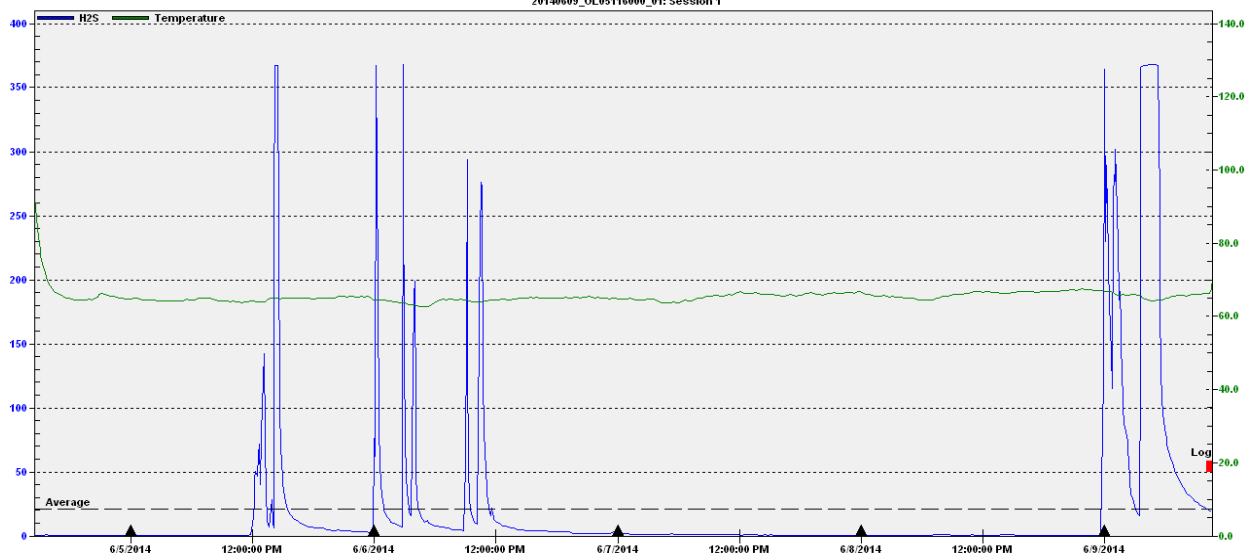
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3. Evaluate the expected frequency of pond use to determine if normal operation should include discharge to the pond for equalization or bypass of the pond with diversion to the pond only when necessary.
 4. Survey the existing City interceptor and topography to confirm the basis of the hydraulic modeling and evaluate the need to divert flows from Micron to UOSA and / or improve the City's interceptor capacity. This evaluation should also consider a review of buildout conditions for any City future capacity needs.
 5. Install sulfide gas detection meters and a flow meter at the Micron force main discharge to understand any hydrogen sulfide formation within the force main

Odor may be caused from numerous sources. Evidence strongly suggests the primary odor source of residential complaints is hydrogen sulfide. Resolving the hydrogen sulfide odor issue may identify sensitivities to other less intense industrial odors that could result in further investigation needs.

Attachment 1

Data

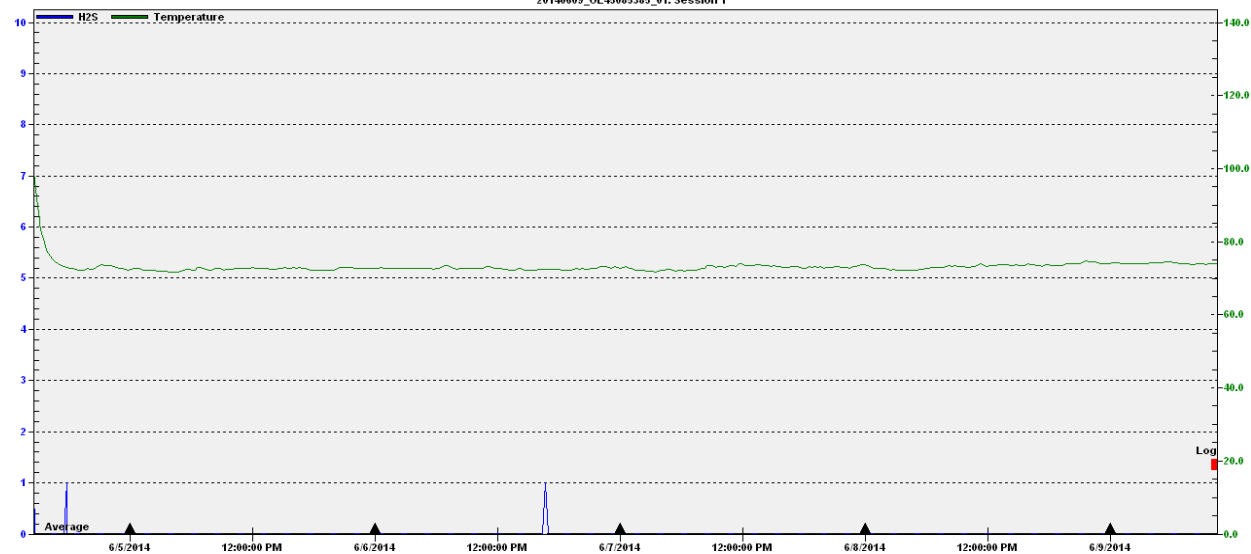
MH 333G Bottom of Hill from Sandy Court
20140609_OL05116000_01: Session 1



Period Displayed: - 6/9/2014 (Oda File: 20140609_OL05116000_01.oda -- Serial Number: OL05116000)

Legend: Average 21PPM ▲ Month Transition Min 0PPM Max 368PPM (Use Screen Data Only)

MH 337G Sandy Court MH
20140609_OL45085385_01: Session 1

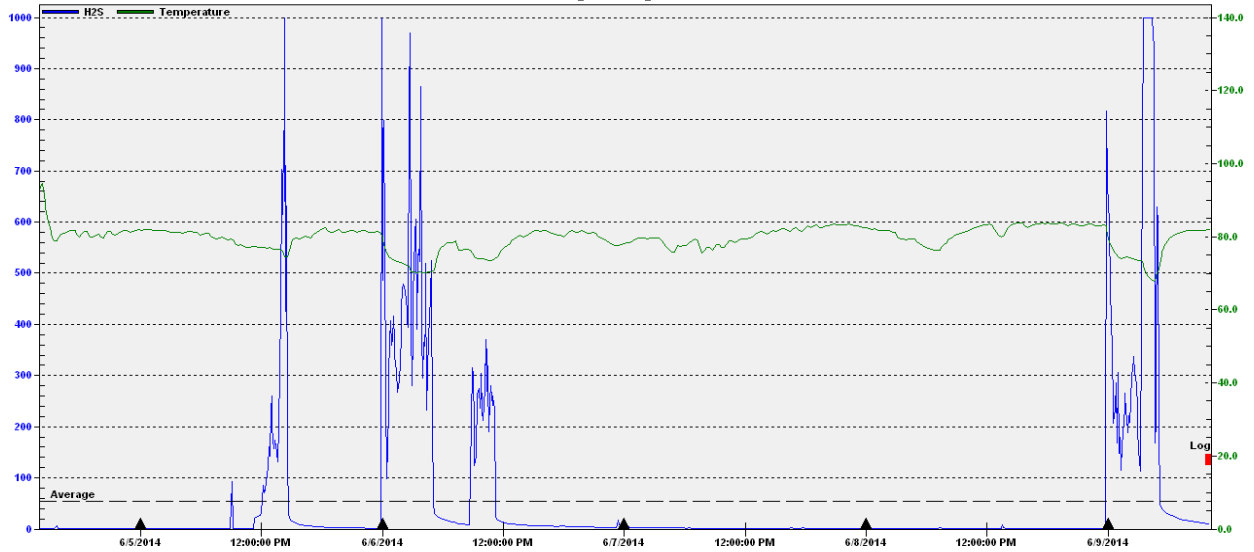


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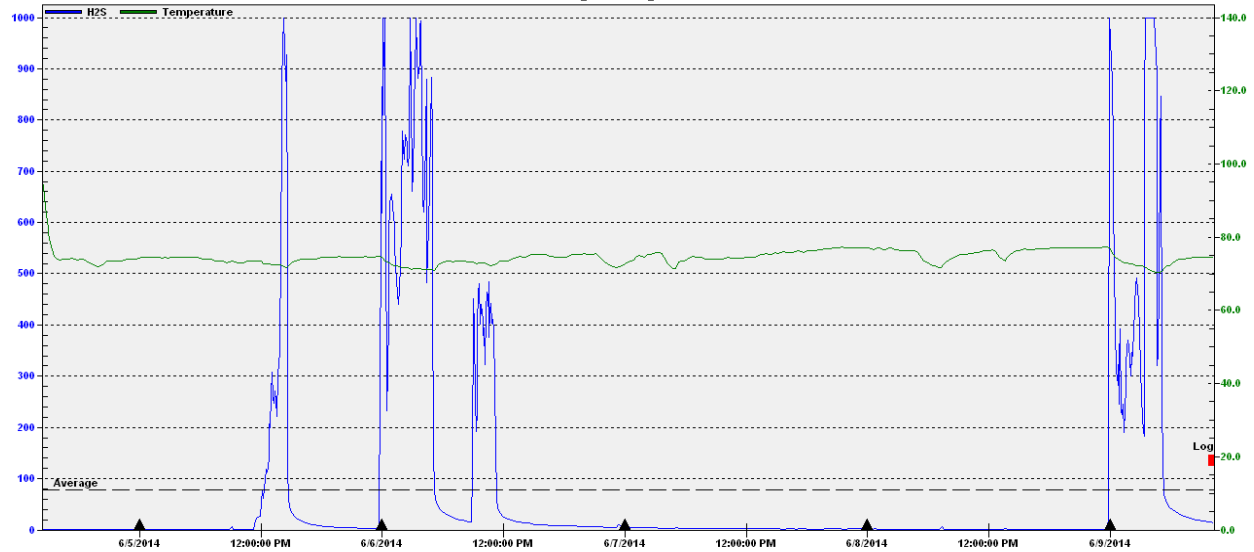
Legend: Average 0PPM ▲ Month Transition Min 0PPM Max 1PPM (Use Screen Data Only)

Manassas Odalog Data

MH 306G Drop MH
20140609_OL45065382_01: Session 1



MH 305G - 2nd MH
20140609_OL45065168_01: Session 1



Sample ID	Date	Time	Collector	pH	Temperature °C	H ₂ O ₂ mg/l.	Turbidity NTU	Weather	Comments
WWC-01	8/20/2018	9:02	IMO	8.01	25.5	9	28.7	Warm and Cloudy	N/A
WWC-02	8/21/2018	8:52	AMA	7.98	25.6	5.5	13.1	Cloudy with light rain.	Water was a light blue
WWC-03	8/22/2018	9:16	IMO	7.66	27.3	9	9.5	Warmy and cloudy.	Water was a light blue.
WWC-04	8/23/2018	9:06	IMO	7.14	26.2	5	13.0	Windy, sunny, and in 60's-70's.	Strong H2S smell at pond. Effluent not as blue as last two days, more gray today.
WWC-05	8/24/2018	9:18	AMA	7.99	26.5	9	9.9	Warm and sunny.	Water more grey than blue.
WWC-06	8/25/2018	9:36	AMA	8.28	26.5	8	16.4	Warm and partly cloudy.	Slight H2S Smell. Water was turquoise color.
WWC-07	8/26/2018	9:33	AMA	7.61	26.1	10	12.0	Warm and sunny.	Water was blue-grey color. 11 drops added to H2O2 test, diluted sampled 1:10, while in lab 18 drops added before color change, 1:10 dilution.
WWC-08	8/27/2018	10:06	IMO	7.86	30.6	5	14.8	Slightly overcast and muggy. Very warm (~80-85 F)	No flow at 9:15-10:04 even with valve opened; water flowed back to sewer [from sampling point] .WB pump station shows irregular pulses of high flow from 8/26-8/27/2018 @730 (FYI, WBPS flows are sanitary+micron industrial WW). Temperature recorded may be higher than actual due to waiting time and ambient air temperature warming the glass sample collectin vessel. Flow smelled strongly sulfidic, much more offensive than previous events.
WWC-09	8/28/2018	9:04	IMO	8.32	28.1	4	26.6	Hot and Sunny.	Water smells sulfidic w/ mercaptans, but not as strongly scented as yesterday @1006. Water dark grey with more solids than previous samples.
WWC-10	8/29/2018	N/A	AMA	N/A	N/A	N/A	N/A	Hot and Sunny.	No discharge. Opened valve at 0855 and closed at 1001, not able to collect sample. Strong to moderate H2S Smell at the pond.
WWC-11	8/30/2018	9:34	AMA	8.46	29.1	4	21.7	Hot, sunny, and windy.	Discharge very grey, and smelled strongly of mercaptans with some sulfide. Foam developed, and continued thru discharge to pond. Waited for discharge to start 0849-0934.
WWC-12	8/31/2018	8:46	IMO	7.74	20.5	4	14.1	Breezy and warm. Mid 70's.	Grey color, not foamy, not as smelly today
WWC-13	9/1/2018	9:20	IMO	7.62	26.9	6	11.1	Warm and overcast. Partial sun, and very light breeze.	Not as smelly as previous days. Grey color, but not foamy.
WWC-14	9/2/2018	9:24	IMO	7.41	26	4.50	17.4	Hot, mostly cloudy & very light breeze	Discharge blueish today - no foam. Not as pungent as previous samples; flow started immediately after valve opened. Pond smell slightly sulfidic today.

ANALYTICAL RESULTS

Project: 18L0464-SULFIDE
Pace Project No.: 92410979

Sample: 18L0464-01 2018-1210 **Lab ID: 92410979001** Collected: 12/10/18 09:30 Received: 12/17/18 10:30 Matrix: Water
SULFIDE

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
4500S2D Sulfide Water								
Analytical Method: SM 4500-S2D-2011								
Sulfide	ND	mg/L	0.10	1		12/17/18 22:31	18496-25-8	

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: 18L0464-SULFIDE

Pace Project No.: 92410979

Sample: 18L0464-01 2018-1211 **Lab ID: 92410979002** Collected: 12/11/18 09:30 Received: 12/17/18 10:30 Matrix: Water
SULFIDE

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
4500S2D Sulfide Water								
Analytical Method: SM 4500-S2D-2011								
Sulfide	ND	mg/L	0.10	1		12/17/18 22:32	18496-25-8	

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: 18L0464-SULFIDE

Pace Project No.: 92410979

Sample: 18L0464-01 2018-1212 **Lab ID: 92410979003** Collected: 12/12/18 09:30 Received: 12/17/18 10:30 Matrix: Water
SULFIDE

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
4500S2D Sulfide Water								
Analytical Method: SM 4500-S2D-2011								
Sulfide	ND	mg/L	0.10	1		12/17/18 23:22	18496-25-8	

REPORT OF LABORATORY ANALYSIS

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Manhole ID	Date	Time	Collector	pH	Temp. °C	Sulfide	Weather	Comments
309G	10/16/18	8:51	IMO	7.60	18.7	ND	Mostly Cloudy & Cool, low 60s w/ light wind	lid open @ 08:48
306GF	10/16/18	9:15	IMO	8.20	20.5	ND	Mostly Cloudy & Cool, low 60s w/ light wind	UOSA collecting composite sample from same sampling point
304G	10/16/18	9:04	IMO	8.06	19.9	ND	Mostly Cloudy & Cool, low 60s w/ light wind	
309G	10/17/18	8:31	IMO	8.41	21.0	ND	Cool, 50s, mostly cloudy	lid open @ 08:30; *pH meter 7.0 post check failed, reading 7.18
306GF	10/17/18	9:03	IMO	8.11	24.9	ND	Cool, 50s, mostly cloudy	*pH meter 7.0 post check failed, reading 7.18
304G	10/17/18	8:51	IMO	7.91	24.4	ND	Cool, 50s, mostly cloudy	*pH meter 7.0 post check failed, reading 7.18
309G	10/18/18	9:32	AMA	7.89	20.2	ND	Cool and sunny	lid open @ 09:30
306GF	10/18/18	9:57	AMA	8.19	23.7	ND	Cool and sunny	
304G	10/18/18	9:46	AMA	8.28	22.2	ND	Cool and sunny	
309G	10/19/18	10:42	IMO	7.85	20.1	ND	Cool, 50s to low 60s, sunny, light wind	lid open @ 10:40
306GF	10/19/18	11:09	IMO	8.76	22.6	ND	Cool, 50s to low 60s, sunny, light wind	
304G	10/19/18	10:05	IMO	8.65	21.4	ND	Cool, 50s to low 60s, sunny, light wind	
309G	10/20/18	7:11	IMO	8.38	18.1	ND	Cool, low 50s, first light at 0657, sunrise at 0724	lid open @ 07:09
306GF	10/20/18	7:35	IMO	8.59	24.0	ND	Cool, low 50s, first light at 0657, sunrise at 0724	Micron discharge very foamy and solids grey and brown instead of just white cotton-like fragments
304G	10/20/18	7:22	IMO	8.41	23.3	ND	Cool, low 50s, first light at 0657, sunrise at 0724	
309G	10/21/18	8:06	IMO	8.46	19.7	ND	Cool, high 40s and windy ~15-20 mph	lid open @ 08:04
306GF	10/21/18	8:29	IMO	8.35	21.3	ND	Cool, high 40s and windy ~15-20 mph	
304G	10/21/18	8:17	IMO	7.93	21.4	ND	Cool, high 40s and windy ~15-20 mph	
309G	10/22/18	9:21	IMO	8.23	18.6	ND	Cool, 30s, clear and sunny	lid open @ 09:19
306GF	10/22/18	9:46	IMO	7.93	22.4	ND	Cool, 30s, clear and sunny	
304G	10/22/18	9:32	IMO	8.12	21.8	ND	Cool, 30s, clear and sunny	

Summary Flow Report



Site:

162A

Hastings Drive R.O.W.

Manassas, VA

24" Circular line

Date	Minimum Flow (mgd)	Peak Flow (mgd)	Total Daily Flow (mg)	Total Rain (in)	Peak Hourly Rain (in)	Peak Interval Rain (in)
10/10/2018 (Wed)	0.817	1.867	0.776	0.00	0.00	0.00
10/11/2018 (Thu)	0.365	2.053	1.292	0.98	0.21	0.04
10/12/2018 (Fri)	0.891	2.032	1.482	0.00	0.00	0.00
10/13/2018 (Sat)	0.764	1.974	1.406	0.03	0.01	0.01
10/14/2018 (Sun)	0.401	2.054	1.393	0.02	0.02	0.01
10/15/2018 (Mon)	0.267	1.875	1.313	0.19	0.12	0.02
10/16/2018 (Tue)	0.319	3.381	1.262	0.00	0.00	0.00
10/17/2018 (Wed)	0.301	1.862	1.250	0.00	0.00	0.00
10/18/2018 (Thu)	0.254	1.748	1.209	0.00	0.00	0.00
10/19/2018 (Fri)	0.220	1.642	1.167	0.02	0.02	0.01
10/20/2018 (Sat)	0.200	1.783	1.213	0.01	0.01	0.01
10/21/2018 (Sun)	0.203	1.923	1.268	0.00	0.00	0.00
10/22/2018 (Mon)	0.194	1.727	1.159	0.00	0.00	0.00
10/23/2018 (Tue)	0.204	1.768	1.127	0.00	0.00	0.00
10/24/2018 (Wed)	0.194	1.707	1.134	0.00	0.00	0.00
10/25/2018 (Thu)	0.211	1.724	1.115	0.00	0.00	0.00
10/26/2018 (Fri)	0.166	1.849	1.164	0.89	0.23	0.03
10/27/2018 (Sat)	0.918	2.754	1.855	0.39	0.09	0.02
10/28/2018 (Sun)	1.087	2.372	1.725	0.02	0.01	0.01
10/29/2018 (Mon)	0.870	2.078	1.486	0.00	0.00	0.00
10/30/2018 (Tue)	0.359	2.184	1.367	0.00	0.00	0.00
10/31/2018 (Wed)	0.290	1.839	1.284	0.00	0.00	0.00
11/1/2018 (Thu)	0.250	1.971	1.269	0.00	0.00	0.00
11/2/2018 (Fri)	0.269	2.301	1.319	0.82	0.54	0.12
11/3/2018 (Sat)	0.902	2.209	1.606	0.02	0.01	0.01
11/4/2018 (Sun)	0.853	2.230	1.546	0.00	0.00	0.00
11/5/2018 (Mon)	0.447	3.227	2.132	1.03	0.34	0.06
11/6/2018 (Tue)	1.478	3.830	2.679	0.63	0.25	0.05
11/7/2018 (Wed)	1.849	3.057	2.410	0.01	0.01	0.01
11/8/2018 (Thu)	0.799	3.240	1.920	0.00	0.00	0.00
11/9/2018 (Fri)	1.098	2.632	1.850	0.48	0.16	0.04
11/10/2018 (Sat)	1.383	2.718	2.033	0.00	0.00	0.00
11/11/2018 (Sun)	1.146	2.570	1.830	0.00	0.00	0.00
11/12/2018 (Mon)	1.008	2.558	1.738	0.62	0.13	0.02
11/13/2018 (Tue)	1.787	3.509	2.705	0.26	0.10	0.02
11/14/2018 (Wed)	1.689	2.762	0.951	0.00	0.00	0.00

Total for period

54.433

6.42

Min: 0.166

Avg: 1.512

Max: 3.830

Flow Analysis Graph

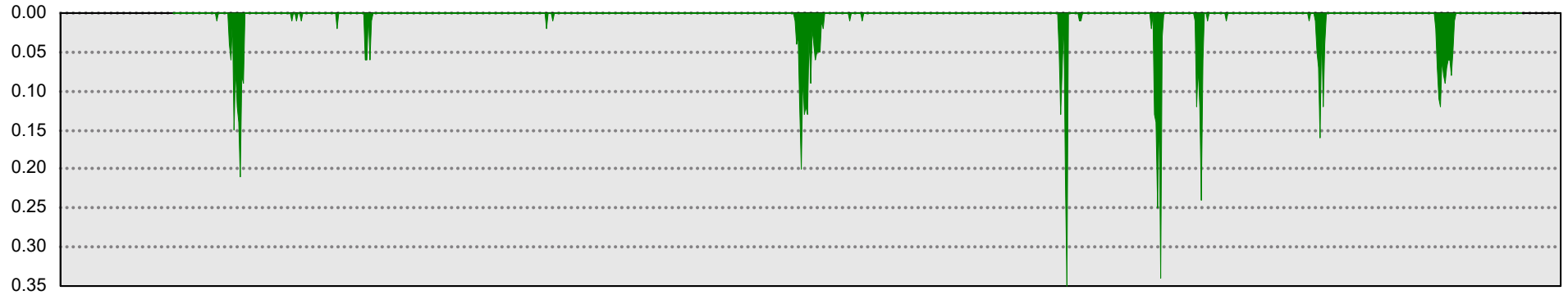
Site:
162A
Hastings Drive R.O.W.

Manassas, VA

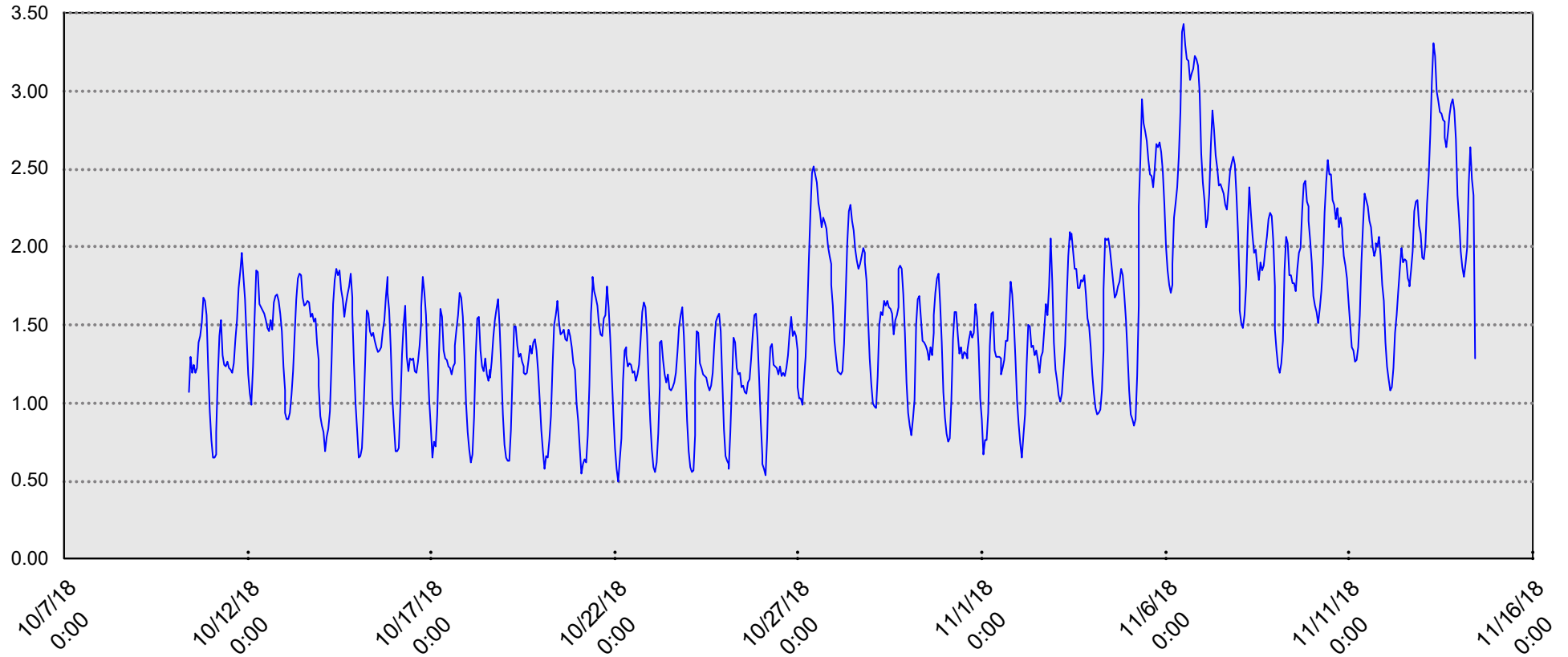


24" Circular line

Rain (in) Printed on: 11/21/2018 Period Covered: 10/10/2018 - 11/15/2018 Every 1 Hour



Flow (mgd)



Summary Flow Report



Site:
305G
Hastings Drive R.O.W.

Manassas, VA

17.5" Circular line

Date	Minimum Flow (mgd)	Peak Flow (mgd)	Total Daily Flow (mg)	Total Rain (in)	Peak Hourly Rain (in)	Peak Interval Rain (in)
10/10/2018 (Wed)	0.983	3.429	0.864	0.00	0.00	0.00
10/11/2018 (Thu)	1.760	3.967	2.718	0.98	0.21	0.04
10/12/2018 (Fri)	1.060	3.816	2.662	0.00	0.00	0.00
10/13/2018 (Sat)	2.053	3.508	2.720	0.03	0.01	0.01
10/14/2018 (Sun)	2.016	3.493	2.558	0.02	0.02	0.01
10/15/2018 (Mon)	0.635	3.649	2.287	0.19	0.12	0.02
10/16/2018 (Tue)	0.980	3.439	2.637	0.00	0.00	0.00
10/17/2018 (Wed)	0.621	3.542	2.572	0.00	0.00	0.00
10/18/2018 (Thu)	0.821	3.744	2.530	0.00	0.00	0.00
10/19/2018 (Fri)	0.843	3.731	2.741	0.02	0.02	0.01
10/20/2018 (Sat)	0.562	3.479	2.495	0.01	0.01	0.01
10/21/2018 (Sun)	1.933	3.587	2.735	0.00	0.00	0.00
10/22/2018 (Mon)	2.091	3.472	2.671	0.00	0.00	0.00
10/23/2018 (Tue)	0.353	3.553	2.501	0.00	0.00	0.00
10/24/2018 (Wed)	0.961	3.523	2.658	0.00	0.00	0.00
10/25/2018 (Thu)	1.015	3.349	2.361	0.00	0.00	0.00
10/26/2018 (Fri)	0.843	3.449	2.577	0.89	0.23	0.03
10/27/2018 (Sat)	1.684	3.819	2.887	0.39	0.09	0.02
10/28/2018 (Sun)	1.281	3.693	2.868	0.02	0.01	0.01
10/29/2018 (Mon)	1.487	3.344	2.593	0.00	0.00	0.00
10/30/2018 (Tue)	0.737	3.285	2.585	0.00	0.00	0.00
10/31/2018 (Wed)	0.629	3.627	2.565	0.00	0.00	0.00
11/1/2018 (Thu)	1.991	3.547	2.572	0.00	0.00	0.00
11/2/2018 (Fri)	0.884	3.531	2.432	0.82	0.54	0.12
11/3/2018 (Sat)	1.005	3.821	2.925	0.02	0.01	0.01
11/4/2018 (Sun)	1.157	3.662	2.775	0.00	0.00	0.00
11/5/2018 (Mon)	0.739	4.525	3.088	1.03	0.34	0.06
11/6/2018 (Tue)	1.209	4.371	3.157	0.63	0.25	0.05
11/7/2018 (Wed)	2.306	3.878	3.237	0.01	0.01	0.01
11/8/2018 (Thu)	1.279	3.735	1.903	0.00	0.00	0.00
Total for period			77.873	5.06		
		Min:	0.353			
		Avg:	2.596			
		Max:	4.525			

Flow Analysis Graph

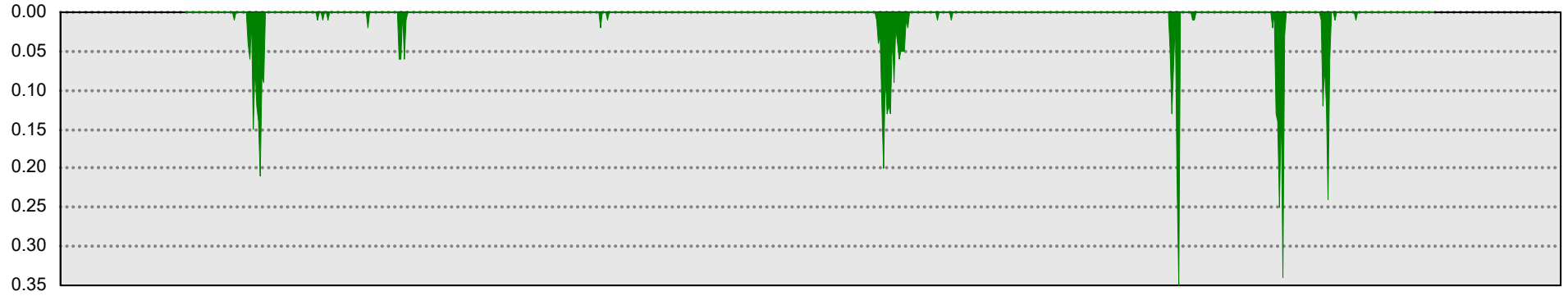
Site:
305G
Hastings Drive R.O.W.

Manassas, VA

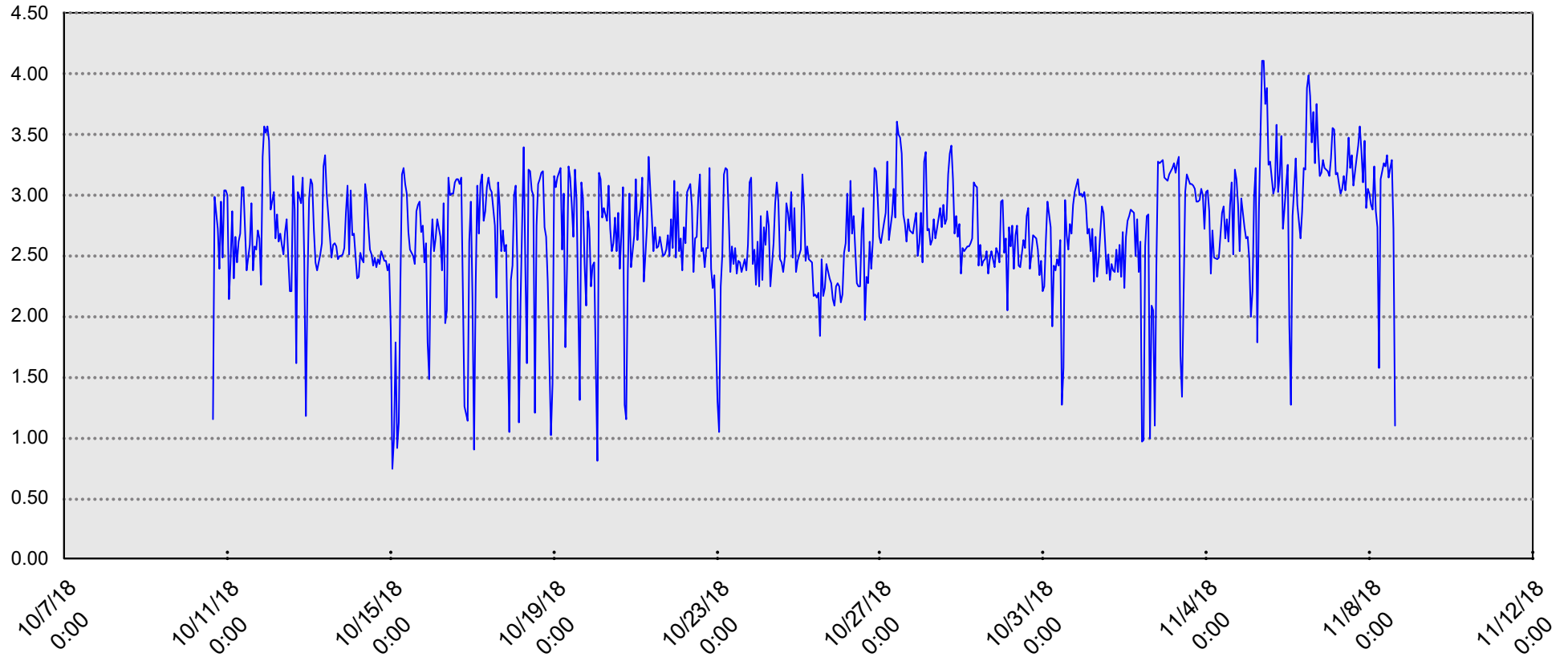


17.5" Circular line

Rain (in) Printed on: 11/21/2018 Period Covered: 10/10/2018 - 11/09/2018 Every 1 Hour



Flow (mgd)



Summary Flow Report



Site:
309G
Hastings Drive R.O.W.

Manassas, VA

18" Circular line

Date	Minimum Flow (mgd)	Peak Flow (mgd)	Total Daily Flow (mg)	Total Rain (in)	Peak Hourly Rain (in)	Peak Interval Rain (in)
10/10/2018 (Wed)	0.000	1.003	0.357	0.00	0.00	0.00
10/11/2018 (Thu)	0.276	1.210	0.718	0.98	0.21	0.04
10/12/2018 (Fri)	0.528	1.121	0.804	0.00	0.00	0.00
10/13/2018 (Sat)	0.374	1.057	0.705	0.03	0.01	0.01
10/14/2018 (Sun)	0.331	1.055	0.686	0.02	0.02	0.01
10/15/2018 (Mon)	0.317	0.993	0.688	0.19	0.12	0.02
10/16/2018 (Tue)	0.283	1.010	0.659	0.00	0.00	0.00
10/17/2018 (Wed)	0.325	0.966	0.661	0.00	0.00	0.00
10/18/2018 (Thu)	0.296	0.979	0.656	0.00	0.00	0.00
10/19/2018 (Fri)	0.292	0.964	0.651	0.02	0.02	0.01
10/20/2018 (Sat)	0.304	1.082	0.698	0.01	0.01	0.01
10/21/2018 (Sun)	0.304	0.978	0.648	0.00	0.00	0.00
10/22/2018 (Mon)	0.264	0.964	0.623	0.00	0.00	0.00
10/23/2018 (Tue)	0.247	1.034	0.649	0.00	0.00	0.00
10/24/2018 (Wed)	0.262	1.063	0.660	0.00	0.00	0.00
10/25/2018 (Thu)	0.288	0.977	0.658	0.00	0.00	0.00
10/26/2018 (Fri)	0.276	0.971	0.676	0.89	0.23	0.03
10/27/2018 (Sat)	0.640	1.414	1.020	0.39	0.09	0.02
10/28/2018 (Sun)	0.517	1.149	0.860	0.02	0.01	0.01
10/29/2018 (Mon)	0.504	1.050	0.779	0.00	0.00	0.00
10/30/2018 (Tue)	0.374	1.023	0.729	0.00	0.00	0.00
10/31/2018 (Wed)	0.365	1.050	0.713	0.00	0.00	0.00
11/1/2018 (Thu)	0.370	0.962	0.680	0.00	0.00	0.00
11/2/2018 (Fri)	0.346	1.359	0.770	0.82	0.54	0.12
11/3/2018 (Sat)	0.642	1.252	0.937	0.02	0.01	0.01
11/4/2018 (Sun)	0.411	1.162	0.848	0.00	0.00	0.00
11/5/2018 (Mon)	0.446	1.786	1.191	1.03	0.34	0.06
11/6/2018 (Tue)	0.792	1.763	1.302	0.63	0.25	0.05
11/7/2018 (Wed)	0.782	1.430	1.110	0.01	0.01	0.01
11/8/2018 (Thu)	0.611	1.222	0.946	0.00	0.00	0.00
11/9/2018 (Fri)	0.522	1.499	1.069	0.48	0.16	0.04
11/10/2018 (Sat)	0.762	1.412	1.084	0.00	0.00	0.00
11/11/2018 (Sun)	0.636	1.420	0.969	0.00	0.00	0.00
11/12/2018 (Mon)	0.606	1.434	1.002	0.62	0.13	0.02
11/13/2018 (Tue)	1.061	1.764	1.407	0.26	0.10	0.02
11/14/2018 (Wed)	0.787	1.382	0.436	0.00	0.00	0.00
		Total for period	29.047	6.42		
		Min:	0.000			
		Avg:	0.807			
		Max:	1.786			

Flow Analysis Graph

Site:
309G
Hastings Drive R.O.W.

Manassas, VA



18" Circular line

Rain (in) Printed on: 11/21/2018 Period Covered: 10/10/2018 - 11/15/2018 Every 1 Hour

