October 2024

SYSTEM EVALUATION AND CAPACITY ASSURANCE PLAN

PREPARED FOR THE

City of Malvern, Arkansas

PREPARED BY

rjngroup

Engineering infrastructure for tomorrow

7304 Kanis Road, Suite 5 | Little Rock, Arkansas 72204 | (501) 224-2248 | www.rjn.com

October 8, 2024

Matt Dunn, P.E.
President
Crist Engineers, INC.
1 Executive Center Court.
Little Rock, AR 72211

SUBJECT: City of Malvern
System Evaluation and Capacity Assurance Plan – Final Report

Dear Mr. Dunn,

In accordance with the March 2023 Engineering Agreement, RJN is pleased to present this final report for the System Evaluation and Capacity Assurance Plan. The activities included building a full system wastewater hydraulic model, calibrating the model with 2023 temporary flow monitoring data, adding future growth projections, developing a capital improvement plan, and providing construction cost estimates for the recommended capital improvement projects.

If you have any questions regarding this submittal or require additional information, please do not hesitate to call us.

Sincerely,
RJN Group, Inc.

Mac Compton, P.E.
Engineering Manager

Daniela S. López, P.E.
Lead Hydraulic Modeler

SYSTEM EVALUATION AND CAPACITY ASSURANCE PLAN

FINAL REPORT

CITY OF MALVERN

STATE OF ARKANSAS
REGISTERED PROFESSIONAL ENGINEER
No. 21809
DANIELA S. LOPEZ LOPEZ
10/08/2024

October 2024

I hereby certify that this report was prepared under my direct supervision and that I am a duly registered Professional Engineer under the laws of the State of Texas.

____

Date: ______10/08/24_________ Registration No.: ____14290___

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This report documents the City of Malvern's (City) System Evaluation and Capacity Assurance Plan (SECAP) for their sanitary sewer collection system. In March 2023, RJN Group, Inc. was retained by the Crist Engineers (Crist) to perform a uniform and comprehensive system-wide evaluation of the wastewater collection system through flow monitoring and the development of a calibrated wastewater hydraulic model. This report outlines the steps taken to build and calibrate the hydraulic model of the City's wastewater collection system, which was subsequently used to develop a SECAP for the sanitary sewer collection system. This report presents the recommended capital improvement projects (CIP) to address the identified hydraulic restrictions in the collection system, along with associated capital costs.

Background & Objective

The City currently owns and operates a sanitary sewer collection system that contains approximately 400,000 linear feet (76 miles) of gravity sewer main, 15 City-owned lift stations, and 89,000 linear feet (17 miles) of forcemain. The wastewater collection system is served by one wastewater treatment plant: Malvern Sewage Treatment Plant.

The primary objective of this project was to build and calibrate a full-system hydraulic model of the wastewater collection system, which included all City-owned gravity sewers, lift stations, and forcemains, and perform a capacity analysis on the system for current flows. The hydraulic capacity issues identified during the capacity analysis would then be used to develop cost-effective CIPs.

Scope

The key stages to develop the SECAP consisted of flow monitoring, hydraulic model development and calibration, hydraulic capacity analysis, and capital improvement recommendations development as detailed below.

Data Collection

A major component of the project was to collect the data that would be used to develop the model of the existing wastewater system. The City's Geographic Information System (GIS) database, field survey of manholes, record drawings, pump curves, pump runtimes, and field investigations were all used as the basis for the sewer's physical network and hydrology parameters found in the model.

Flow and Rainfall Monitoring

Nine (9) temporary area-velocity meters and five (5) rain gauges were installed and maintained by RJN for the 2023 flow monitoring survey. The manhole sites for these meters were selected to strategically capture flow measurements and divide the wastewater system into evenly distributed catchments as best as possible.

The flow monitoring period used for model calibration is from April 5, 2023, through June 13, 2023.

Full-System Hydraulic Model Development and Calibration

Autodesk's InfoWorks ICM version 2023.2 was used to develop a comprehensive full-system model of the City's sewer network that contained all existing sewer mains, lift stations, and force mains and explicitly modeled each property parcel connected to the sewer network as a standalone sub-catchment. The full-system model was developed using all the data collected in earlier stages of the project, including the City's GIS, manhole survey, field inspections, as-built data, and LiDAR elevation data.

The flow and survey data collected during the flow monitoring period were used to calibrate the base model for both dry and wet-weather conditions. The following tasks were included in this phase of the project:

- Develop dimensionless dry-weather flow profiles from observed flow data to modulate residential flow projections.
- Assign industry-appropriate non-residential dimensionless flow profiles to all commercial and industrial sub-catchments.
- Calibrate model to dry-weather diurnal weekday and weekend conditions.
- Calibrate wet-weather flows based on all observed rainfall events.

Design Storm Selection & Level of Service (LOS)

RJN reviewed the performance of the system under the 1-, 2-, and 5-year design storms of 1- and 6-hour durations. After analyzing the system during each of these rainfall events and discussions with Crist and the City, the 2-year, 6-hour design storm (3.11 inches) was selected to develop CIP recommendations for the City.

The Level of Service (LOS) defines an achievable performance capacity the City would like to provide to its customers. Through a series of workshops with the City, the selected LOS was determined to be if the surcharging in the sewer reached within 2-feet of the ground and if there was a predicted SSO.

Capacity Analysis

A hydraulic capacity analysis was performed by applying the 2-year, 6-hour design storm to the calibrated hydraulic model to confirm areas with insufficient capacity and identify deficiencies in the collection system. The capacity focused on current conditions, excluding considerations for future growth.

Capital Improvement Plan

Based on the capacity analysis, alternative solutions were evaluated to resolve existing capacity constraints in gravity mains, lift stations, and force mains to develop cost-effective CIPs. CIP development included analyzing but was not limited to inflow and infiltration (I/I) abatement, constructing proposed sewer mains, upsizing or paralleling existing sewers, upgrading or modifying pump stations, upsizing or paralleling existing force mains, adding flow equalization facilities, and general operation improvements.

Recommendation Summary

The provided recommendations are designed to contain the peak wet-weather flows resulting from the 2-year, 6-hour design storm with all future developments.

Capital Improvement Projects (CIPs)

Seven (14) CIPs were developed to resolve predicted SSOs during the 2-year, 6-hour design storm:

CIP Cost Summary			
#	Project	Project Description	Capital Cost
1	A	Proposed 7 MGD Pump Station	$5,531,500
2	A	Proposed 20" Force Main	$2,991,300
3	A	Chatman Creek Sewer Diversion & Upsizing	$2,962,050
4	A	Flow Equalization System	$1,862,250
5	W	Walco Rd PS Evaluation	$20,000
6	S	Sewer System Rehabilitation	$3,010,000
7	W	Walco Rd PS Proposed 20" Force Main	$3,111,600
8	W	Walco Rd PS Rehabilitation	$487,500
9	B	North Sewer Interceptor Upsizing	$3,091,075
10	C	Burris Rd Sewer Upsizing	$3,412,110
11	D	Mill St Sewer Upsizing	$2,815,475
12	E	Sulphur Springs Rd Sewer Upsizing	$1,265,550
13	F	Wilson St & Park Ave Sewer Pipe Burst	$379,340
14	G	Sullenberger Ave Sewer Pipe Burst	$371,020
		TOTAL	**$31,310,770**

Recommendation Benefits

There are many benefits to completing the recommendations. Completing this work will help the City to continue delivering service to its customers by addressing the following issues:

- Root intrusions and other defects causing I/I
- Undersized pipes for and existing conditions causing SSOs
- End-of-life materials that are likely to fail or already demonstrating problems
- Segments where larger pipes transition to smaller diameters leading to backups in the system
- Other maintenance-related concerns (e.g., grease traps or rags)

Conclusion

RJN developed a capital improvement plan to address the capacity issues identified in the capacity analysis for existing conditions. The total opinion of probable cost for all recommendations is **$31,310,770**. The proposed capital improvement plan will supplement the City's ongoing efforts to continually improve the system and allow for the City's continued growth and prosperity.

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

SECTION 1

INTRODUCTION AND PROJECT OBJECTIVES

rjngroup
Engineering infrastructure for tomorrow

1 Introduction and Project Objectives

In March 2023, RJN Group, Inc. (RJN) was retained by Crist Engineers (Crist) to perform a comprehensive wastewater collection system analysis and develop a System Evaluation and Capacity Assurance Plan (SECAP) for the City of Malvern, Arkansas.

The sanitary sewer collection system evaluation consisted of performing flow monitoring to determine dry and wet-weather flows in the system and prioritizing the areas with excessive amounts of inflow and infiltration (I/I). Wet-weather flows were analyzed to identify which areas of the system contribute excess I/I to the sewer system.

Additionally, the evaluation consisted of building and calibrating a hydraulic model to be used for the evaluation of the sanitary sewer system's capacity to convey existing flows. The capacity assessment would then be used to develop a system-wide collection system capital improvement plan. This report details the steps taken to build and calibrate the hydraulic model of the City's wastewater collection system used to develop a comprehensive Wastewater Collection SECAP. The report contains the recommended capital improvement projects (CIP) to address the elimination of known sanitary sewer overflows (SSOs) and additional capacity issues identified by the hydraulic model, along with associated capital costs.

1.1 Background

The City owns and operates a wastewater collection system that contains approximately 400,000 linear feet (75 miles) of gravity sewer main, eight City-owned lift stations, and 89,000 linear feet (17 miles) of forcemain. The wastewater collection system is served by one wastewater treatment plant located on the east side of the City.

The primary objective of this project was to build and calibrate a full system hydraulic model of the wastewater collection system, which included all City-owned gravity sewers, lift stations, and forcemains, and to perform a capacity analysis on the system for current and future flows to develop cost-effective CIPs. The key stages of the Master Plan consisted of flow monitoring, hydraulic model development and calibration, hydraulic capacity analysis, and the development of capital improvement recommendations.

Figure 1-1, on the next page, includes a map showing the City's wastewater collection system.

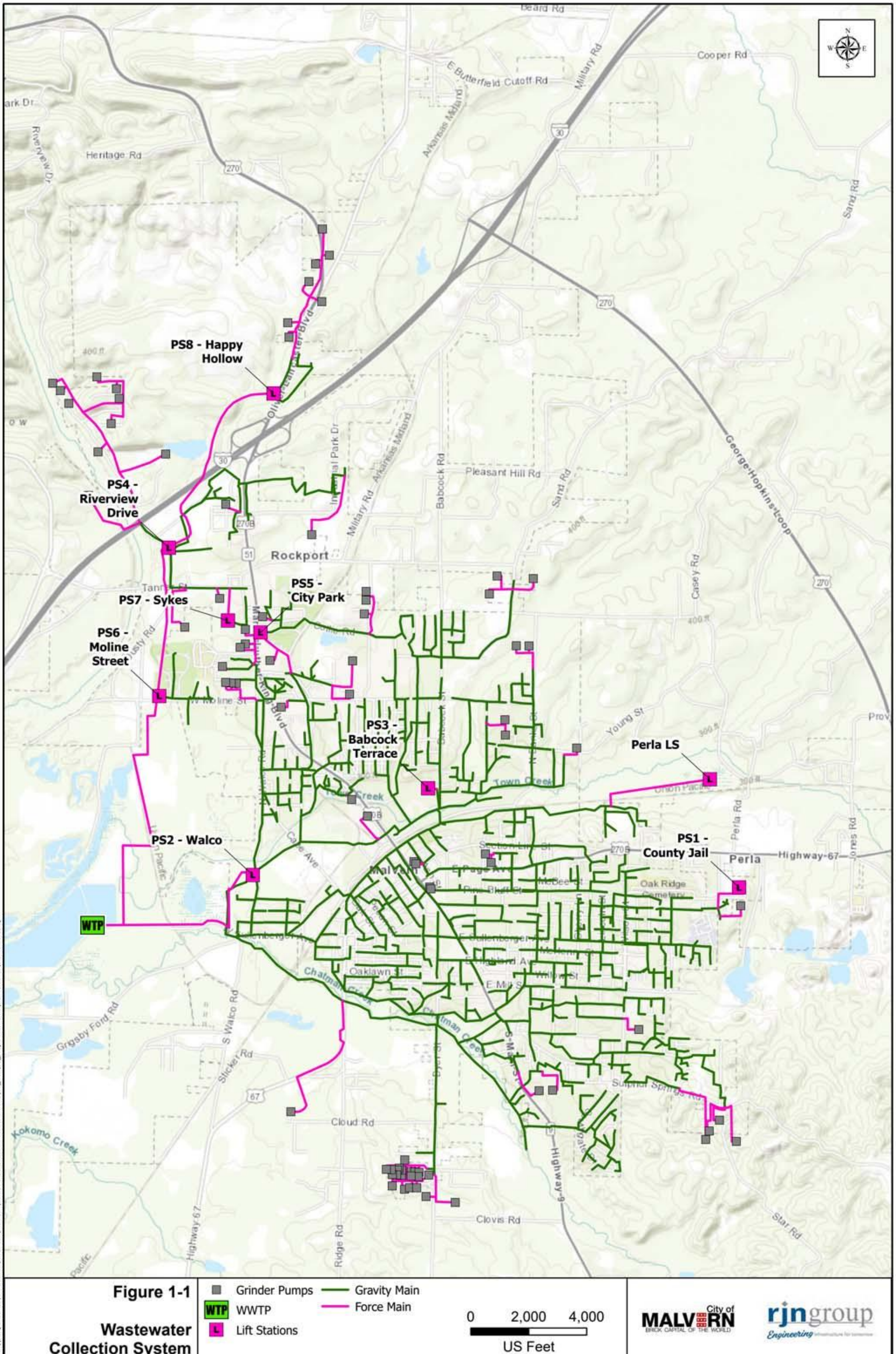


Figure 1-1

Wastewater Collection System

Path: \\dal-panzura1\OFFICE-18\Arkansas\Malvern\18-3979-00 2023 PM Model Smoke\05_GIS\02_MapDocuments\Deliverables\Deliverables.aprx

1.2 Objectives

The following are the key Master Plan objectives:

- Collect available data from the City necessary to build a full-system hydraulic model network.
- Conduct a short-term wastewater flow monitoring and rain gauge survey.
- Calibrate the hydraulic model with the data collected from the flow monitoring period.
- Determine the design storm and level of service (LOS) for capacity evaluation.
- Simulate the design storm conditions on the calibrated model and identify existing capacity deficiencies under existing conditions.
- Develop cost-effective capital improvement projects that address existing capacity issues.
- Provide a costed CIP for the agreed LOS to address capacity deficiencies.

1.3 Scope

The following is a summary of the work undertaken to complete this project which is then detailed in the subsequent sections.

1.3.1 Data Collection

A major component of the project was to collect the data that would be needed to develop the model of the existing wastewater collection system. Field inspection of manholes (performed by in previous project), record drawings, pump curves, pump runtimes, historical reports, and design drawings were all used as the basis for the sewer's physical network and hydrology parameters in the model. The collection and processing of this data are detailed in Chapters 2 and 3 of this report.

1.3.2 Flow and Rainfall Data for Hydraulic Model Calibration

Nine (9) temporary area-velocity meters and five (5) rain gauges were installed and maintained by RJN for the 2023 flow monitoring survey. The manhole sites for these meters were selected to strategically capture flow measurements and divide the wastewater system into evenly distributed catchments as best as possible.

During regularly scheduled maintenance visits, RJN field personnel conducted a series of performance and calibration tests to verify that the equipment met established operating standards. The following activities were included during routine maintenance visits:

- In-situ depth and velocity confirmations
- Sensor cleaning
- Defective or deficient equipment replacement, as needed

1.3.3 Full-System Hydraulic Model Development

Autodesk's InfoWorks ICM version 2023.2 software was used as the platform for the modeling analysis. InfoWorks ICM is a fully dynamic hydraulic model capable of analyzing both gravity and pressurized components of complex sewer systems.

The key objective of this task was to create a comprehensive full-system model of the City's sewer network that included all existing sewer mains, lift stations, and forcemains and explicitly modeled each property parcel connected to the sewer network as a standalone sub-catchment.

This full-system model was used as the basis for the subsequent calibration.

1.3.4 Hydraulic Model Calibration

The flow and survey data collected during the flow monitoring period were used to calibrate the base model for both dry and wet-weather conditions. The following tasks were included in this phase of the project:

- Develop dimensionless dry-weather flow (DWF) profiles from observed flow data to modulate residential flow projections.
- Assign industry-appropriate non-residential dimensionless flow profiles to all commercial and industrial sub-catchments.
- Calibrate the model to dry-weather diurnal weekday and weekend conditions.
- Calibrate wet-weather flows based on all observed rainfall events.

1.3.5 Design Storm Selection & Level of Service

RJN reviewed the performance of the system under the 1-, 2-, and 5-year design storms of 1- and 6-hour durations. After analyzing the system during each of these rainfall events and discussions with Crist and the City, the 2-year, 6-hour design storm (3.11 inches) was selected to develop CIP recommendations for the City. The design storm distribution is based on the National Oceanic and Atmospheric Administration (NOAA) Atlas 14's methodology for the 1st Quartile, 50th percentile probability.

The Level of Service (LOS) defines an achievable performance capacity the City would like to provide to its customers. Defining the LOS is paramount to developing a cost-effective capital improvement plan. Through a series of workshops with the City and Crist, the selected LOS was determined to be if the surcharging in the sewer reached within 2-feet of the ground and if there was a predicted SSO. This LOS was used to identify when a capital improvement project was necessary and used in determining adequate sizing to resolve identified capacity issues.

1.3.6 Capacity Analysis

A hydraulic capacity analysis compares model-predicted flow rates to existing conveyance capacities and estimates the elevation of the hydraulic grade line (HGL) in the system, including the magnitudes of surcharging and flooding in the collection system. The analysis is performed by applying a design storm condition to the hydraulic model to identify hydraulic deficiencies in the collection system.

The selected 2-year, 6-hour design storm was used to evaluate system capacity, identify bottlenecks in the collection system, and develop a list of CIPs.

1.3.7 Capital Improvement Plan

This task included developing necessary improvement alternatives to transport the projected wastewater flows to the determined LOS during both existing and future conditions. The following tasks were included in this phase:

- Develop improvement plans for existing projected wet-weather flows with targeted I/I reduction in critical areas of the system to meet LOS.
- Develop improvement plans for wet-weather flows to meet LOS.
- Determine peak wastewater flows to the WWTPs.
- Develop a comprehensive CIP for the collection system.

SECTION 2

FLOW AND RAINFALL MONITORING

2 Flow and Rainfall Data Summary

Flow data provides the essential information needed to calibrate the model, assess the hydraulic performance of the wastewater system, and identify areas of hydraulic overloading, capacity restrictions, and excessive inflow and infiltration.

Nine (9) temporary area-velocity meters and five (5) rain gauges were installed and maintained by RJN for the 2023 flow monitoring survey. The manhole sites for these meters were selected to strategically capture flow measurements and divide the wastewater system into evenly distributed catchments as effectively as possible.

The flow monitoring period used for model calibration was from April 5 through June 15, 2023.

Each flow monitor was strategically placed to capture flow measurements for accurate flow analysis. A schematic of the monitoring network is illustrated in Figure 2-1. Figure 2-2 shows an overall map of the flow meter and rain gauge locations.

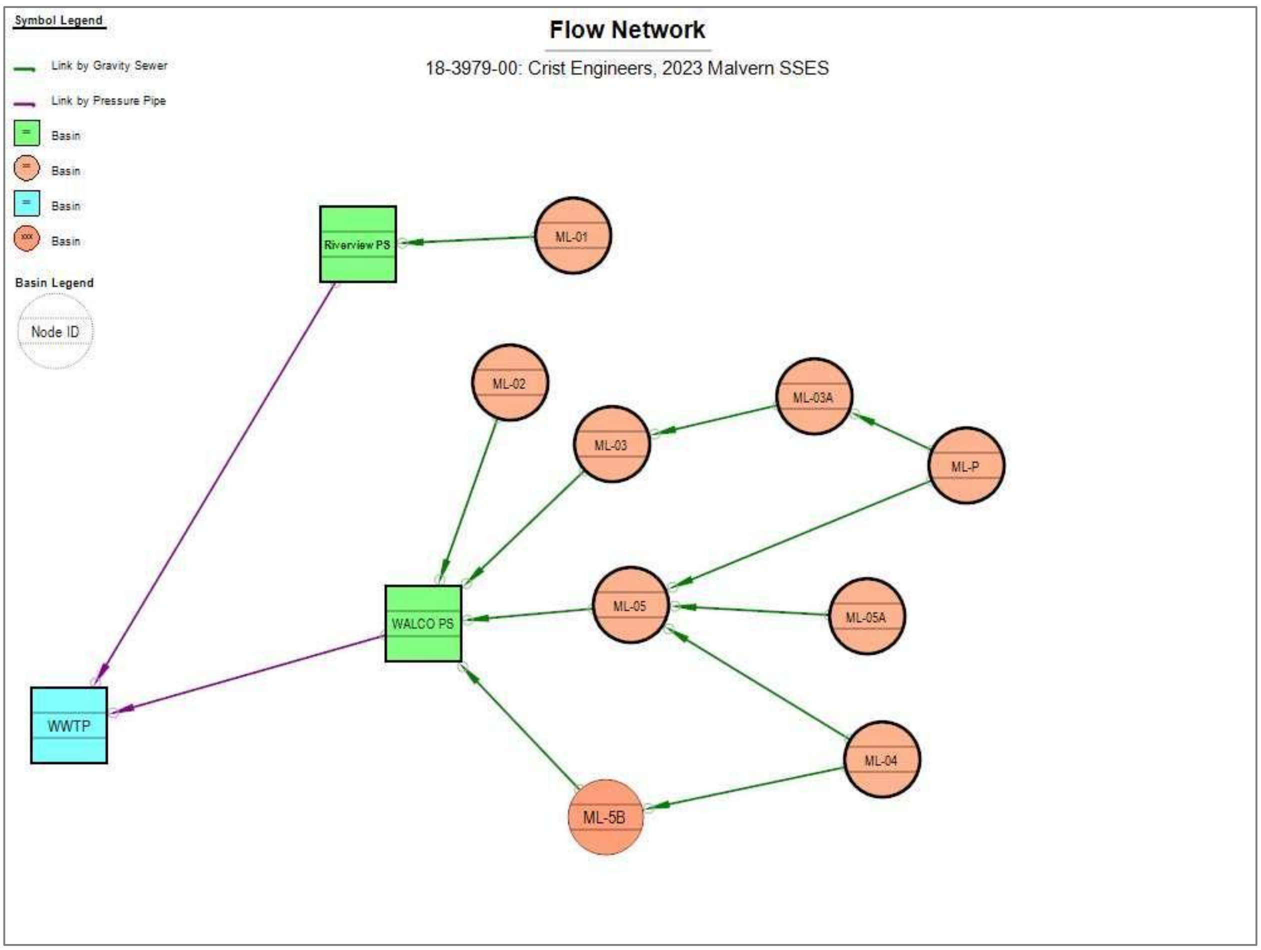
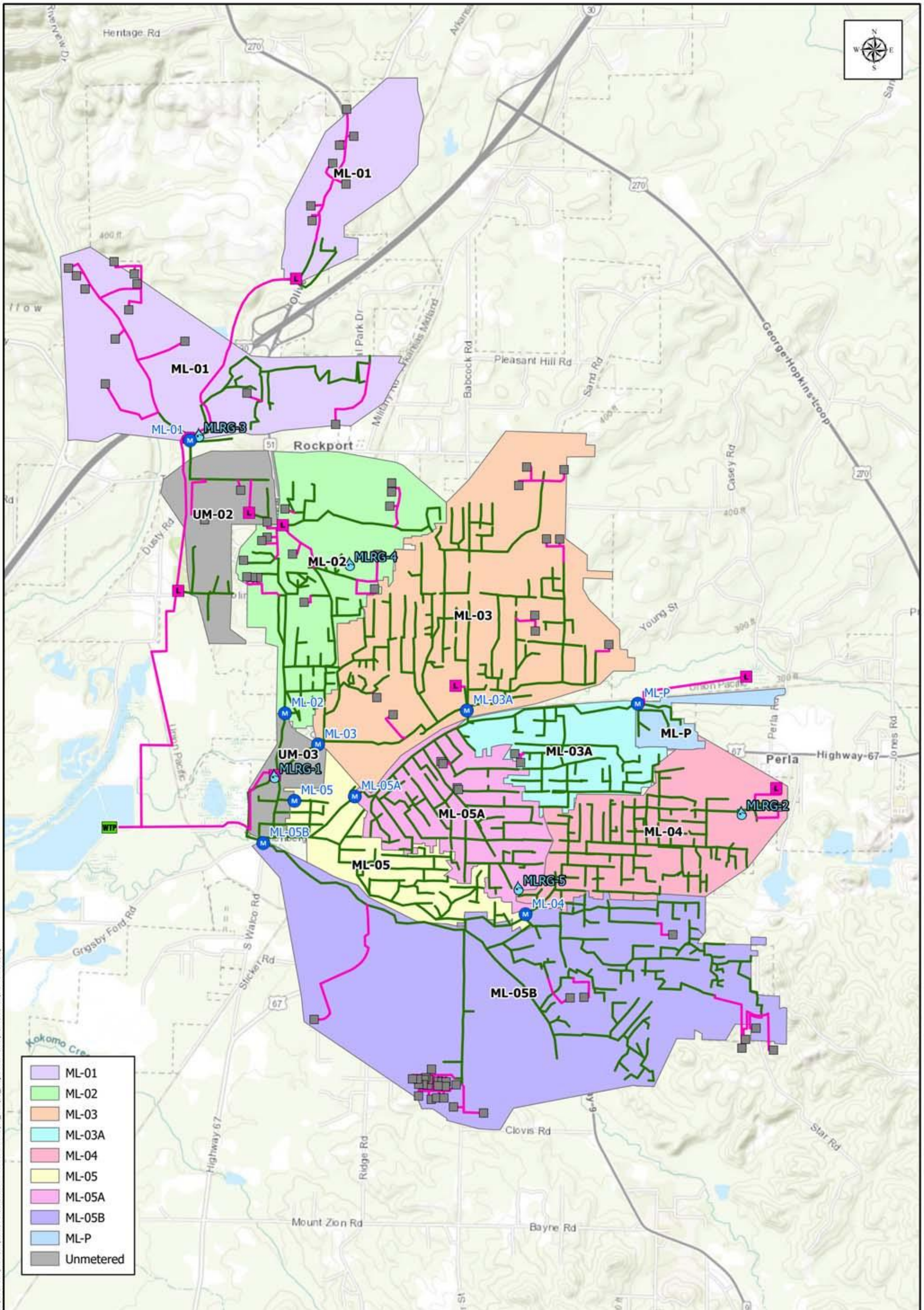


Figure 2-1. Flow Monitoring Schematic



Path: \\dal-panzura1\OFFICE-18\Arkansas\Malvern\18-3979-00 2023 PM Model Smoke\05_GIS\02_MapDocuments\Deliverables\Deliverables.aprx

Figure 2-1

Wastewater Collection System

Meter Locations
Rain Gauges
WWTP
Lift Stations
Grinder Pumps
Force Main
Gravity Main

0 2,000 4,000
US Feet

City of MALVERN BRICK CAPITAL OF THE WORLD

rjn group Engineering infrastructure for tomorrow

2.1 2023 Temporary Flow Monitors

Nine (9) temporary area-velocity meters were installed and maintained by RJN for the 2023 flow monitoring period. The sites for these meters were selected to strategically capture flow measurements and divide the wastewater collection system into evenly distributed catchments as effectively as possible.

Following the review of the wastewater collection system as detailed in RJN's field inspections, initial locations were selected that indicated favorable conditions for monitoring flows. Ideally, these locations had a straight channel through the manhole and would be free of turbulence or backwater effects. RJN crews then undertook detailed site investigations to confirm that the identified locations provided favorable conditions for monitoring flows. In some cases, it was necessary to also assess the in-situ hydraulic conditions at upstream or downstream manholes when the initial sites were found to be unsuitable.

Pipe heights and widths were measured during the inspections to enable accurate flow calculations, with diameters ranging from 6 to 24 inches. The measured dimensions were also incorporated into the hydraulic model.

Table 2-1. Flow Meter Locations

Flow Meter Locations				
			Pipe Dimensions	
Meter Site Number	**Manhole Number**	**Site Address**	**Pipe Height (in)**	**Pipe Width (in)**
ML-01	MH_NE_1581	Riverview Dr near PS4	9.68	9.88
ML-02	MH_NE_1445	125 S Walco Rd	9.75	9.75
ML-03	MH_NE_0538	314-398 Cabe Ave	14.54	14.0
ML-03A	MH_NE_1460	121 Babcock St	10.06	10.06
ML-04	MH_NW_1415	1814 S Main St	10.06	9.94
ML-05	MH_NW_1416	1320 Kelly St	14.75	14.88
ML-05A	MH_NW_1456	815 Burris Rd	12.00	11.81
ML-05B	MH_NW_1406	1125 Turner St	14.54	14.00
ML-P	MH_NW_2098	1616 E Page Ave	7.75	7.52

The flow monitoring program ran from April 5 through June 15, 2023. The temporary meters were regularly serviced during the 2023 flow monitoring period and flow data was processed at the end of the period. To ensure that the equipment was operating properly, the following activities were completed during site visits:

- Meters were inspected;
- Manual depth and velocity measurements were taken;
- Silt deposit depths were recorded;
- Batteries were tested and changed if necessary

2.2 2023 Rainfall Data

Five continuously recording tipping bucket rain gauges were installed across the system and maintained by RJN to monitor rainfall during the flow monitoring period. The rain gauges recorded data every five minutes with an accuracy of 0.01 inches. The rain gauges were equipped with their RTUs and called in once per day to relay data to RJN's central database.

The rain gauges recorded five rainfall events of greater than 1-inch of rainfall over a 24-hour period. However, there was significant spatial variation of rainfall intensities across the system. The largest storm by average rainfall depth occurred on April 29, 2023, with an average of 1.95 inches. On the other hand, the event with the highest rainfall intensity occurred on April 5, 2023, with an average peak hour intensity of 0.72 inches per hour.

The average total rainfall recorded from April 5, 2023, to June 12, 2023, was 9.41 inches.

A summary of all the rainfall events observed greater than 0.25 inches at each gauge is shown in Table 2-2 on the following page.

Table 2-2. 2023 Rainfall Summary

Rainfall Summary		MLRG-01		MLRG-02		MLRG-03		MLRG-04		MLRG-05	
Start Date/Time	**Estimated Event Duration, hrs**	**Total Rainfall Depth, in**	**Peak Hour Intensity, in/hr**	**Total Rainfall Depth, in**	**Peak Hour Intensity, in/hr**	**Total Rainfall Depth, in**	**Peak Hour Intensity, in/hr**	**Total Rainfall Depth, in**	**Peak Hour Intensity, in/hr**	**Total Rainfall Depth, in**	**Peak Hour Intensity, in/hr**
4/5/2023 9:00	**5.0**	1.51	1.02	1.41	1.01	1.18	0.61	1.43	0.83	1.38	0.97
4/15/2023 18:10	**1.6**	0.11	0.10	0.69	0.46	0.06	0.06	0.28	0.27	0.56	0.45
4/20/2023 18:00	**10.9**	1.32	0.64	1.56	0.75	1.49	0.60	1.43	0.60	1.45	0.75
4/25/2023 16:15	**5.1**	0.42	0.14	0.44	0.14	0.40	0.16	0.43	0.16	0.43	0.14
4/26/2023 2:15	**3.8**	0.50	0.28	0.51	0.29	0.47	0.26	0.52	0.26	0.53	0.28
4/29/2023 0:00	**10.1**	2.02	0.97	2.03	0.72	1.96	0.89	1.84	0.85	1.88	0.66
5/10/2023 13:20	**2.9**	0.65	0.34	0.66	0.28	0.57	0.29	0.62	0.30	0.70	0.30
5/10/2023 23:05	**13.2**	1.57	0.86	1.60	0.78	1.55	0.78	1.42	0.78	1.43	0.80
5/19/2023 20:30	**2.5**	0.90	0.52	0.66	0.42	1.59	1.03	1.19	0.66	0.78	0.41

2.3 Data Evaluation

For each site, a scattergraph was created to compare the depth versus velocity relationship. The results from the meter site visits were recorded in the maintenance logs and then entered into RJN-owned proprietary software for computing average velocities and theoretical Manning's slope based on the manual measurements. Manning's flow value was then calculated based on the average equivalent slope for all the meter services and an initial comparison was made to the continuity equation flow value calculated from the manual measurements.

To further ensure meter data quality, Manning's flows are used as a tool for data evaluation in developing a trend line relationship for comparison to flows derived by the continuity equation. The Manning equation and the continuity equation graphs are overlaid to review if there are any significant variations. Some exceptions for using the Manning equation include flow conditions where backwater or surcharging conditions are present. In these cases, the measured flow rates do not necessarily follow those predicted by Manning's equation.

Hydrographs were prepared to show the response that was present at each meter as a result of I/I in the tributary basin. Figure 2-3 below shows a typical hydrograph.

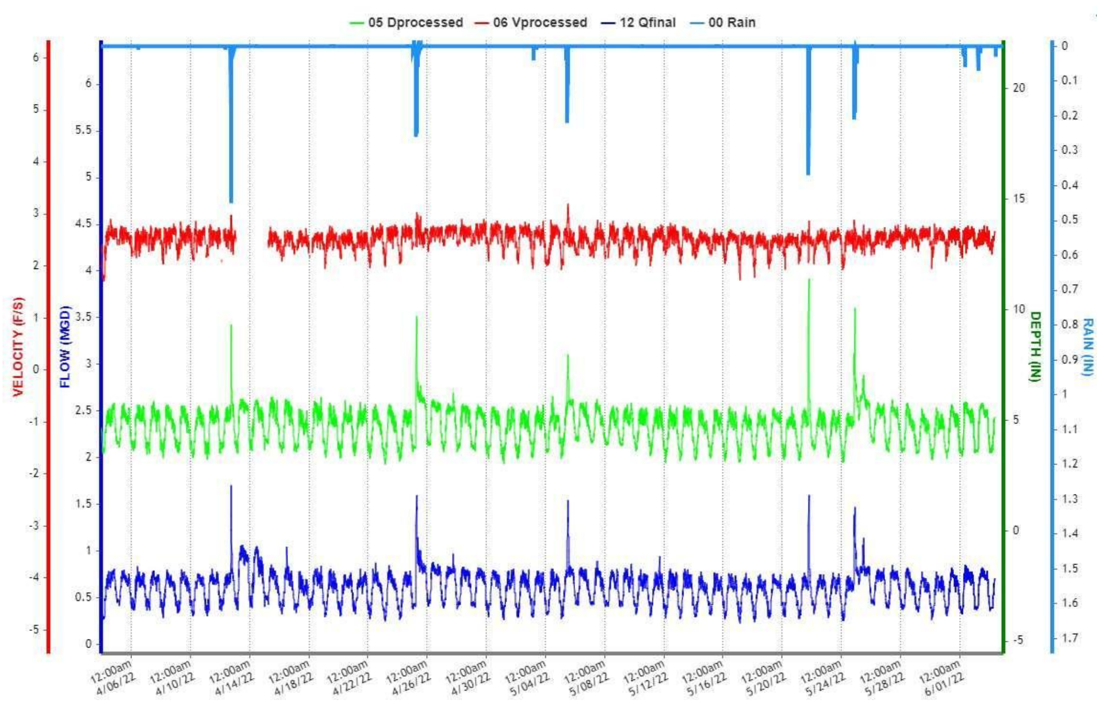


Figure 2-3. Typical Hydrograph

SECTION 3

MODEL DEVELOPMENT AND CALIBRATION

rjngroup Engineering infrastructure for tomorrow

3 Model Development and Calibration

This chapter provides an overview of the tasks involved in the development and calibration of the hydraulic model used to develop the Wastewater Collection System Master Plan for the City.

The computer-based hydraulic model of the wastewater system developed for this project needed to fulfill the following key requirements:

- Reflect the performance of the existing sanitary sewer system.
- Provide a suitably flexible platform for analyzing existing system performance.
- Enable testing and optimizing of augmentation options to service and contain existing flows.

3.1 Model Description

The key tasks of building a hydraulic model for the Master Plan were:

- Create a comprehensive full-system model of the City's sewer network that contains all existing sewer mains, lift stations, and forcemains and explicitly model each property parcel connected to the sewer network as a standalone sub-catchment.
- Calibrate the model using flow and rainfall data collected during the flow monitoring program conducted between April and June 2023.
- Use the calibrated model to evaluate the existing system capacity to transport DWF.
- Develop a 2-year, 6-hour design storm using NOAA Atlas 14 distribution.
- Simulate the selected design storm on the existing system to identify areas with insufficient capacity that do not meet the LOS.
- Develop capital improvement projects to meet the City's LOS.

3.2 Model Network Development

A range of data sources was used in the development of the existing and augmented network models. These sources included:

- collection system network GIS databases,
- manhole field survey data,
- 1-meter DEM data,
- property parcels,
- lift station as-builts,
- pump curves,
- selected sanitary sewer as-built and design plans.

Flow metering data, 2020 census data, and water billing data were used to allocate DWF contributions within the model down to the individual property parcel level. The following sections detail the data sources and their application.

3.2.1 Collection System Network GIS

The primary source of data used in the development of the model of the existing wastewater network was the City's GIS sewer database. The manholes, gravity mains, lift stations, and forcemains were uploaded into InfoWorks ICM to create the base pipe and manhole network for the model. The GIS was not populated with elevation or pipe diameter data, but the City had conducted manhole inspections that were used to populate the sewer depth and diameter sizes.

The manhole-pipe connectivity, as well as the flow directions for the gravity sewers, required substantial review and rectification to create a base network that was fully traceable from upstream to downstream. RJN reviewed connectivity issues and discrepancies with the City providing clarification on correct connectivity.

A QA/QC review of the GIS data included full system tracing and the identification and removal of pipes and nodes that are disconnected from the rest of the system. Gaps in the GIS database were addressed with data collected by field investigations.

3.2.2 Manhole Survey Data

Crist undertook an extensive manhole survey effort to ensure high-quality elevational data along key parts of the sewer system. Approximately 277 manholes (18-percent of manholes in the system) were located and surveyed under this program. The work included a sub-centimeter survey to record manhole rim elevations, and measured sewer line diameters and depth to the invert of the sewer main elevation entering or leaving the manholes. Crist provided the survey data in a geodatabase.

The survey information was imported into InfoWorks ICM to update the modeled pipes and manholes, and these updates were flagged accordingly in the hydraulic model based on their data source.

3.2.3 Ground Models from LiDAR Data

LiDAR data at a 1-meter resolution was sourced from the Arkansas GIS Office (AGO) and imported into InfoWorks ICM to create a Digital Terrain Model (DTM). The DTM was then applied across the hydraulic model network and used to interpolate a rim elevation for every manhole in the network. Approximately 82% of the modeled manholes have rim elevations interpolated from the DTM.

3.2.4 Hydraulic Model Network Clean-Up

The surveyed pipe elevations were input into the model. The non-surveyed pipe elevations were derived from the extensive manhole inspections the City previously conducted. Missing elevational data were initially estimated based on minimum pipe grades and adjusted as necessary until the complete network gravitated to the local pumping stations.

Some as-built plans were sourced to provide more detailed information on certain portions of the network.

3.2.5 Property Parcels

GIS property parcels were retrieved from the Census TIGER database and then imported into the InfoWorks ICM model as sub-catchments. In addition to providing comprehensive details about each property, zoning codes were utilized to differentiate each property as being either residential or non-residential. Each parcel-based sub-catchment was assigned to discharge into the most appropriate manhole within the model network to load flows into the model. Areas such as parks, creeks, major roadways, etc. that are not connected to the sewer system have been omitted as they do not contribute any wastewater flow or I/I into the sewer system.

3.2.6 Lift Station Dimensions, Pump Curves, and Operating Levels

Eight City-owned lift stations have been represented in the model. The Perla Lift Station, which pumps into the City's collection system, was also integrated into the model. Additionally, 84 grinder pumps were identified and represented in the model.

Partial or complete as-built plans were provided for five City-owned lift stations. The as-builts were used to determine lift station dimensions (i.e., wet well diameters and depths). Operating levels were provided by the City at seven of the eight City-owned lift stations. These were used to accurately represent the lift station operations in the model. All other operating levels were assumed. Table 3-1 includes the wet well dimensions provided by the City.

Pump curves were supplied for seven of the lift stations and those have been input into the model. The remaining lift station was modeled with an estimated fixed pump discharge rate.

Table 3-1. Lift Station Details

Lift Station Details					
Lift Station Name	**Address**	**Wet-Well Depth, Feet**	**Wet-Well Diameter, Feet**	**Forcemain Diameter, in**	**Pump Curves Received?**
PS1 - County Jail	1 Detention Ln	10	6	4	Yes
PS2 - Walco	712 Walco Rd	26.5	10	8	Yes
PS3 - Babcock Terrace	107 Babcock Terr.	12.5	4	6	Yes
PS4 - Riverview Drive	Riverview Dr and Riley St	11.0	4	6	Yes
PS5 - City Park	Park Dr and Pavilion Rd	29.1	12	8	Yes
PS6 - Moline Street	1840 Moline St	12.0	4	4	Yes
PS7 - Sykes	1601 MLK Blvd	9.8	4	4	No
PS8 - Happy Hollow	3199 Oliver Lancaster Blvd	20.0	7	6	Yes

3.2.7 Census Data

Population data was sourced from the 2020 U.S. Census. Residential properties were identified as being located within the sanitary sewer system using the parcel data from the City.

As illustrated in Figure 3-1, the available census data blocks are generally at a very high level of resolution within the City, down to a street block level. A total existing sewershed population of 8,386 was calculated using this method.

Each residential property was initially assigned a DWF profile that defined an initial per capita flow rate of 70 gallons per capita per day (gpcd).

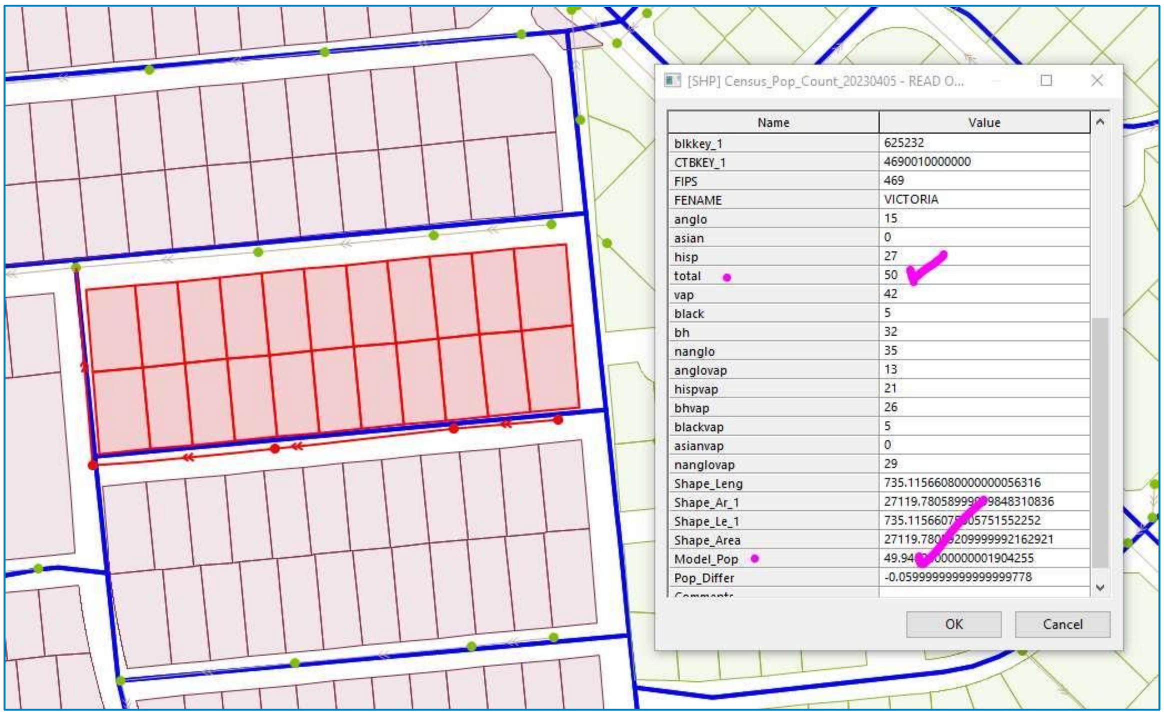


Figure 3-1. Census Data Distribution Example

3.2.8 Water Billing Data

Water billing data was provided for the majority properties and was processed to establish an average water consumption per day, as illustrated in Figure 3-2. For non-residential properties, an assumption was made that 90% of the water entering the properties was returned to the sewer, and this flow rate was used as the initial flow loading in the model from non-residential properties. The water usage data that were processed and applied in the model were from January through December 2022.

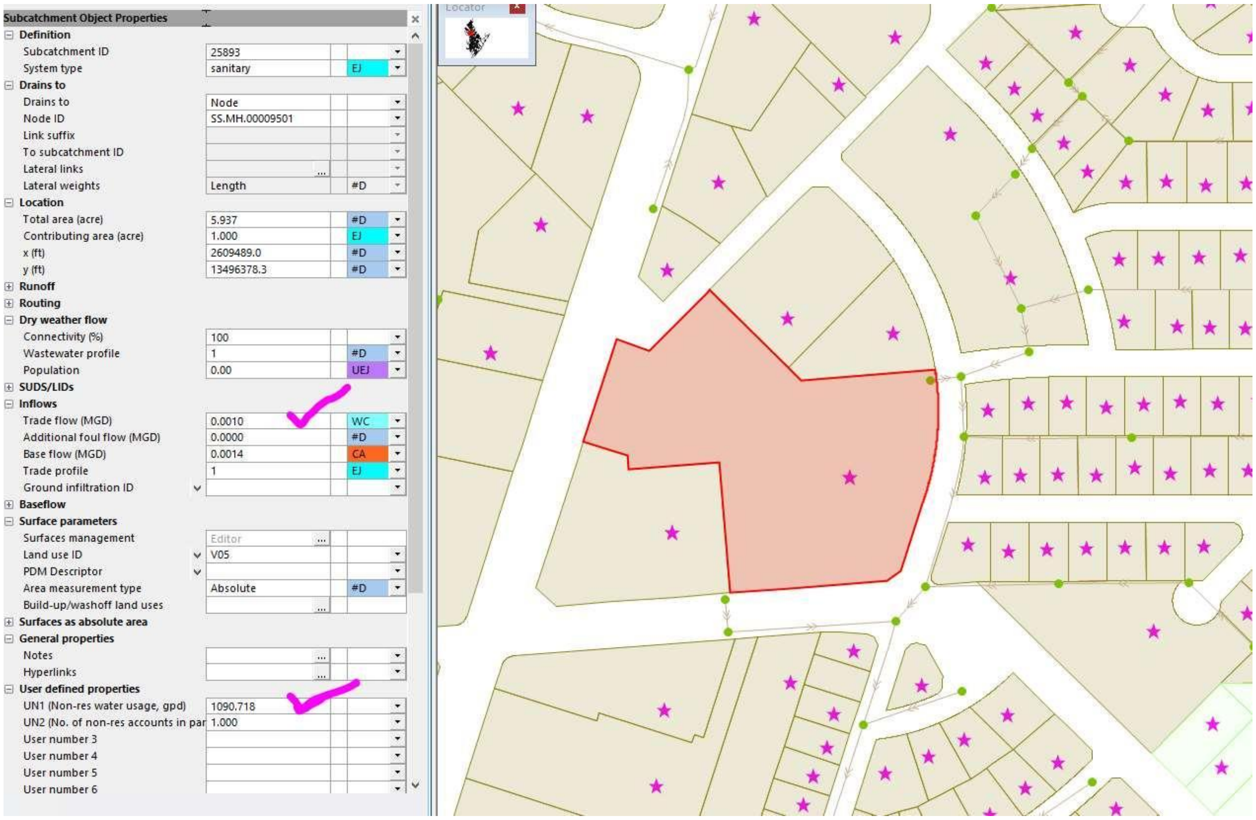


Figure 3-2. Water Consumption Loading Example

3.3 Model Hydrology Development

The data sources defined in the previous section were imported into the InfoWorks ICM model, processed, and validated to create a base model of the network suitable for commencing DWF calibration.

3.3.1 Model Software

The model was developed using InfoWorks ICM V2023.2.3 software by Autodesk. This software allows for a fully dynamic hydraulic model capable of analyzing large, complex sewer systems, including overflows with an integrated 1D/2D engine. InfoWorks ICM allows for full surcharging, flow attenuation, and backwater conditions. It also supports siphons, parallel pipes, and reverse flow. I/I can be applied as constant or time-varying inflow or as rainfall-generated runoff routing and groundwater infiltration. Pump stations and forcemains are modeled using a fully integrated RTC module. Various tools are available such as load allocation tools and automated network data validation. InfoWorks ICM fits the modeling requirements for this system analysis and allows for future refinement of the model as data becomes available or as changes to the system are made.

3.3.2 Initial Dry-Weather Flow Loading

DWFs in the hydraulic model are comprised of three primary components:

- Residential sanitary flows
- Non-residential sanitary flows (or commercial and industrial flows)
- Permanent groundwater infiltration (GWI)

3.3.2.1 Residential Sanitary Flows

Residential flows are generated in the model from the population assigned to each residential property, the selected per capita flow rate, and the dimensionless profile assigned to each property. Figure 3-3 on the following page illustrates the dimensionless profile developed from the recorded flow data at flow meter ML-05A, which was applied to all residential properties in the ML-05A basin with an estimated daily per capita flow of 70 gpd.

3.3.2.2 Non-Residential Sanitary Flows

Non-residential flows are generated in the model from the daily flows assigned to each non-residential property, based on factored water consumption, and the selected dimensionless profile assigned. Figure 3-4 on the following page illustrates the typical non-residential dimensionless profiles assigned in the model.

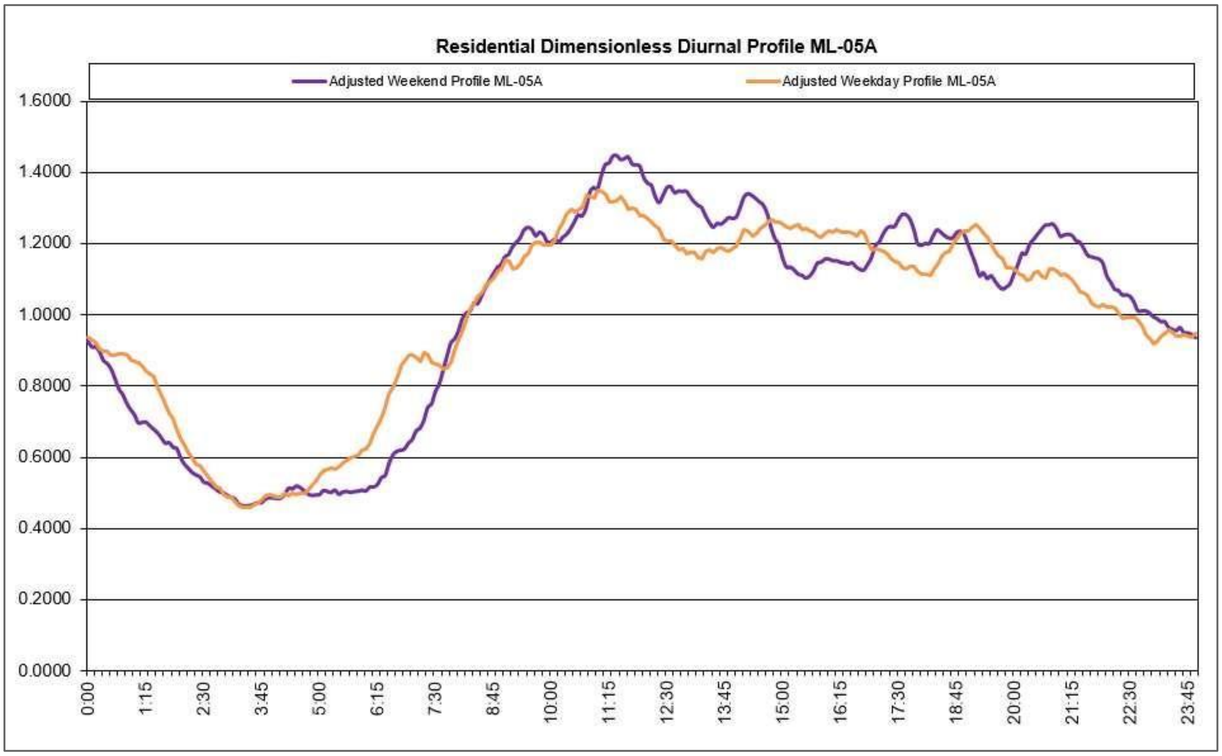


Figure 3-3. NE01 Residential Diurnal Profile

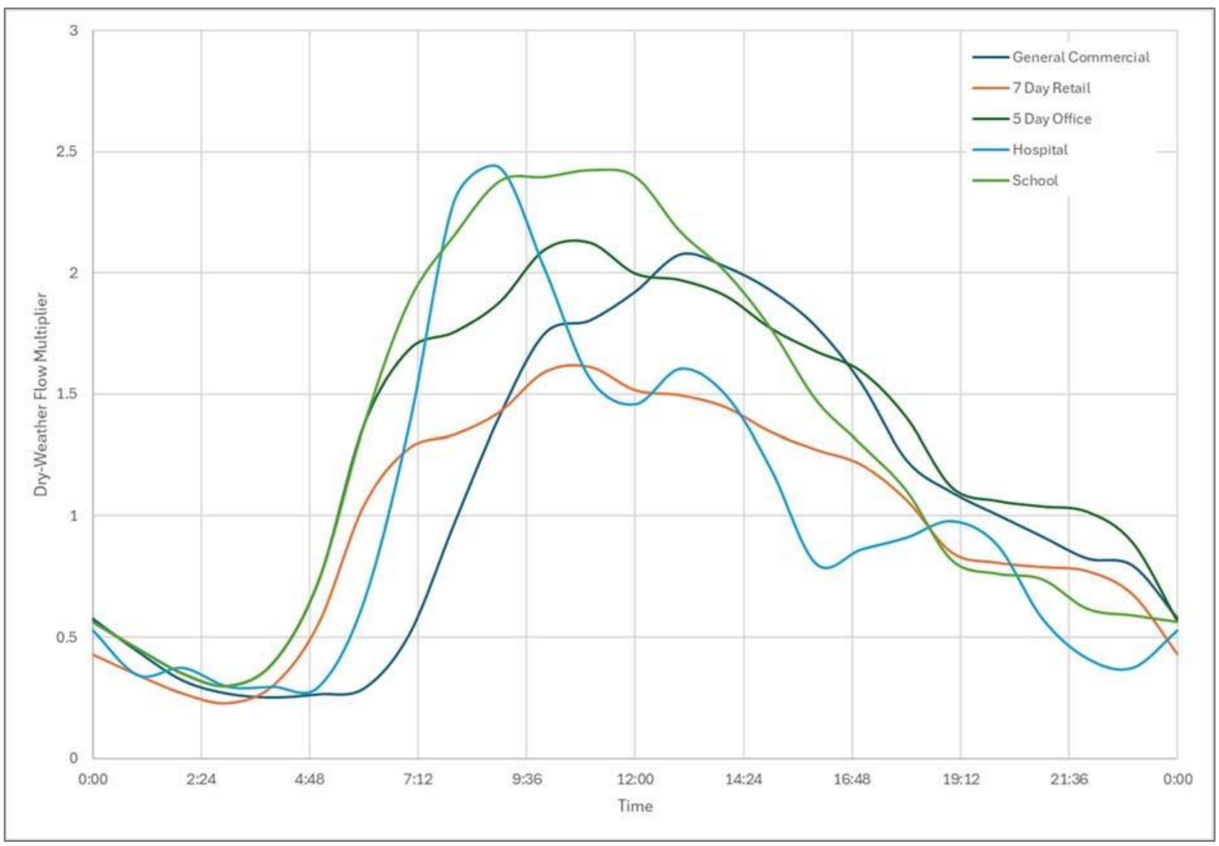


Figure 3-4. Non-Residential Dimensionless Profile

3.3.2.3 Permanent Groundwater Infiltration

GWI is the non-rainfall-dependent infiltration that enters the sewer system through misaligned pipe joints and cracks from both private property and the main public sewer network. GWI is estimated by subtracting the total average DWF from the residential and non-residential flow estimates.

3.3.2.4 Model Validation

Following the completion of the assignment of DWFs across the network, the hydraulic model was run for an initial seven-day validation simulation. This initial test simulation highlighted some minor errors in the model, which were rectified. The rectified model successfully passed the subsequent validation simulation and was considered a suitable platform for dry and wet-weather calibration.

3.4 Model Calibration

Calibrating the hydraulic model is necessary for the model to accurately represent the behavior of the sanitary sewer system. Calibration is a process through which model variables and coefficients are adjusted through multiple iterations until modeled flow, depth, and velocity reasonably match the flow meter data recorded during the survey. The model is calibrated to recreate sewer performance under both dry and wet-weather conditions. It is important to note that the model does not use flow survey data as input to generate flows; instead, this data is used to verify that the flows developed deterministically in the model align well with the recorded observed flows.

3.4.1 Dry-Weather Flow Calibration

DWF calibration is the first step in the overall calibration process and helps identify potential issues with the hydraulic model construction.

Calibrating the model for DWF was achieved by modifying the following items:

- Residential per capita flow rates and diurnal patterns
- Non-residential flow rates and diurnal patterns
- Non-time-varying GWI rates

Dry-weather calibration ideally requires at least seven days unaffected by any additional derived flows resulting from rainfall. This period must also include at least one weekend. The recorded flow data was assessed in conjunction with the rainfall data to assess the best period for this analysis.

Site calibrations for DWFs were considered satisfactory when the following qualifications were met:

- Modeling dry-weather volume (represented by the average flow rate) was within +/-10-percent of the measured dry-weather volume.
- The modeled diurnal pattern is qualitatively similar to the measured pattern.

Table 3-2 shows the results of the dry-weather calibration.

Table 3-2. DWF Calibration Summary

	7-Day Volume (MG)		
Meter Sites	**Observed**	**Modeled**	**Difference**
ML-01	0.624	0.655	5%
ML-02	0.522	0.544	4%
ML-03	2.879	2.928	2%
ML-03A	0.882	0.928	5%
ML-04	2.120	2.054	-3%
ML-05	1.670	1.786	7%
ML-05A	0.721	0.759	5%
ML-05B	11.060	11.055	0%
ML-P	0.159	0.156	-2%

All calibration sites were within the calibration guidelines, therefore, a satisfactory level of DWF calibration was achieved across the network. Appendix A contains the hydrographs showing observed versus modeled results at each site during dry-weather.

3.4.2 Wet-Weather Calibration

Wet-weather calibration is the process by which the recorded rainfall is applied to the model, and hydrological parameters are adjusted until a suitable match is achieved between observed and modeled flows.

Wet-weather flows were generated in the model using up to three "fixed" response surface areas calibrated for each sub-catchment. The fixed responses ranged from:

- Short, quick responses to rainfall, indicative of illegally connected house drains or cross-connections with the stormwater system. These responses typically dissipate soon after the rainfall ceases as illustrated by the blue hydrograph in Figure 3-5.

- Slower, delayed responses, representative of rainfall percolating into the pipe trench and then entering the sewer through cracks or misaligned pipe joints. These responses typically peak sometime after the rain and may continue for many hours or even days as illustrated by the green hydrograph in Figure 3-5.

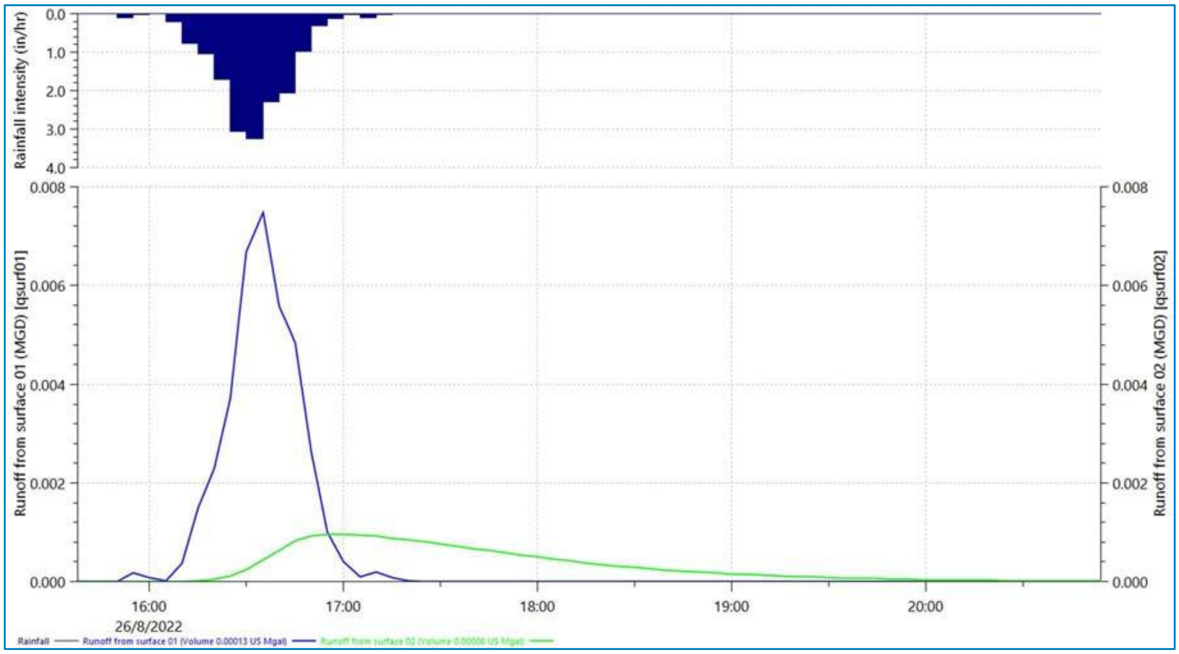


Figure 3-5. Typical Fast and Slower Wet Weather Response

Similar to the DWF calibration, the modeled wet-weather flows were calibrated using industry standards. At each monitoring location, the observed peak flow rate and volume were initially compared to modeled predictions for all significant wet-weather events. An example is illustrated in Figure 3-6 showing the full-period comparison of modeled flows (green) with observed flows (blue) at meter ML-03.

The following guidelines were used at each flow monitoring location to evaluate the quality of the wet-weather flow calibration:

- Model wet-weather event volume is +20 to -10 percent of the observed volume.
- Model wet-weather peak flow rate is +25 to -15 percent of the observed peak flow rate.
- The general pattern of wet-weather flow response, in terms of timing and shape, matched the observed wet-weather response.

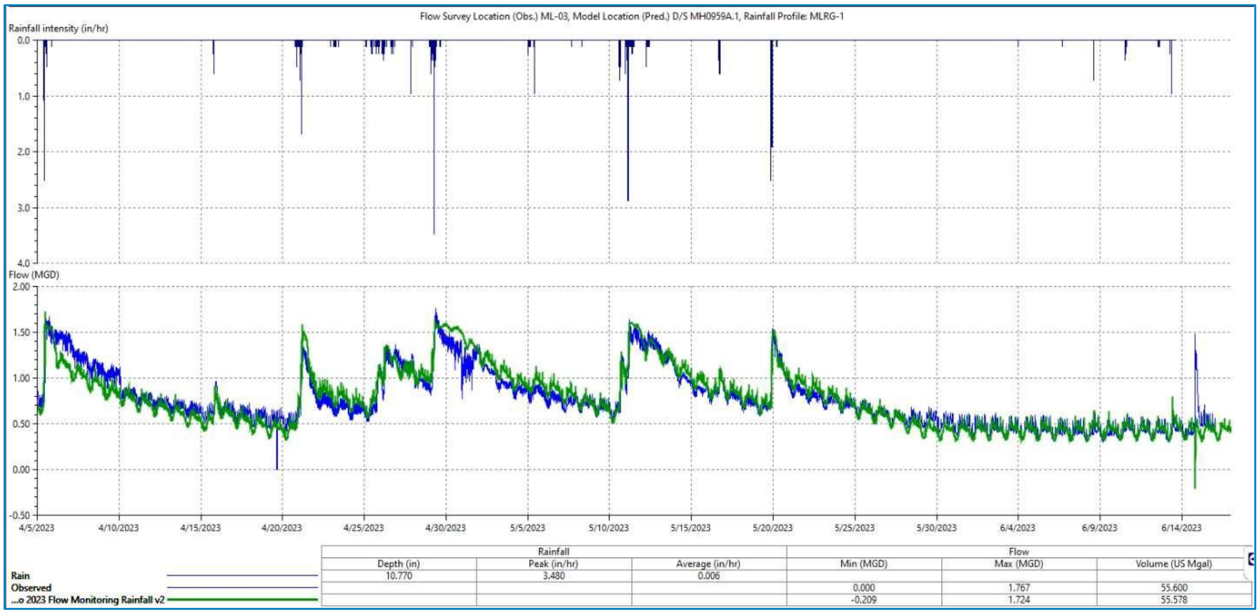


Figure 3-6. Full Period Wet-Weather Calibration at ML-03

The criteria are not meant as a pass/fail litmus-type test, but rather serve as a guide to evaluate the quality of the calibration at each meter. Calibrations that meet these criteria should be considered to have a high level of confidence in results produced from the model applications. Calibrations that do not meet this criterion can still have a high level of confidence in model results but should identify any limitations for using the model in subsequent capacity alternatives evaluations.

The model is considered suitably calibrated for undertaking system performance and CIP development.

Appendix B contains the hydrographs showing observed versus modeled results at each site for the full flow monitoring period.

SECTION 4

Calibration Period Observations

4 Calibration Period Observations

The following are noteworthy observations of the flow monitoring period that were extensively discussed with the City and Crist.

4.1 Walco Lift Station Performance

The Walco Lift Station pump curves were provided and integrated into the model. According to the pump curves and other lift station attributes received, the Walco Lift Station should be able to handle a peak flow of approximately 5.0 MGD. However, based on the flow monitoring data collected, the lift station is pumping a maximum flow rate of approximately 3.8 MGD. This means that the lift station is not operating as intended.

Additionally, even if the lift station were operating at its intended design flow rate, the lift station is undersized to convey the peak flow rates recorded during the flow monitoring period. The lack of capacity at Walco Lift Station causes significant surcharging across the system for prolonged periods of time after a rainfall event. During the flow monitoring period, four out of the nine flow meters were directly impacted by the backups caused by the Walco Lift Station: ML-02, ML-03, ML-05, and ML-05B. Figure 4-1 shows an example of the prolonged surcharging observed at ML-03 after the April 5, 2023, rainfall event.

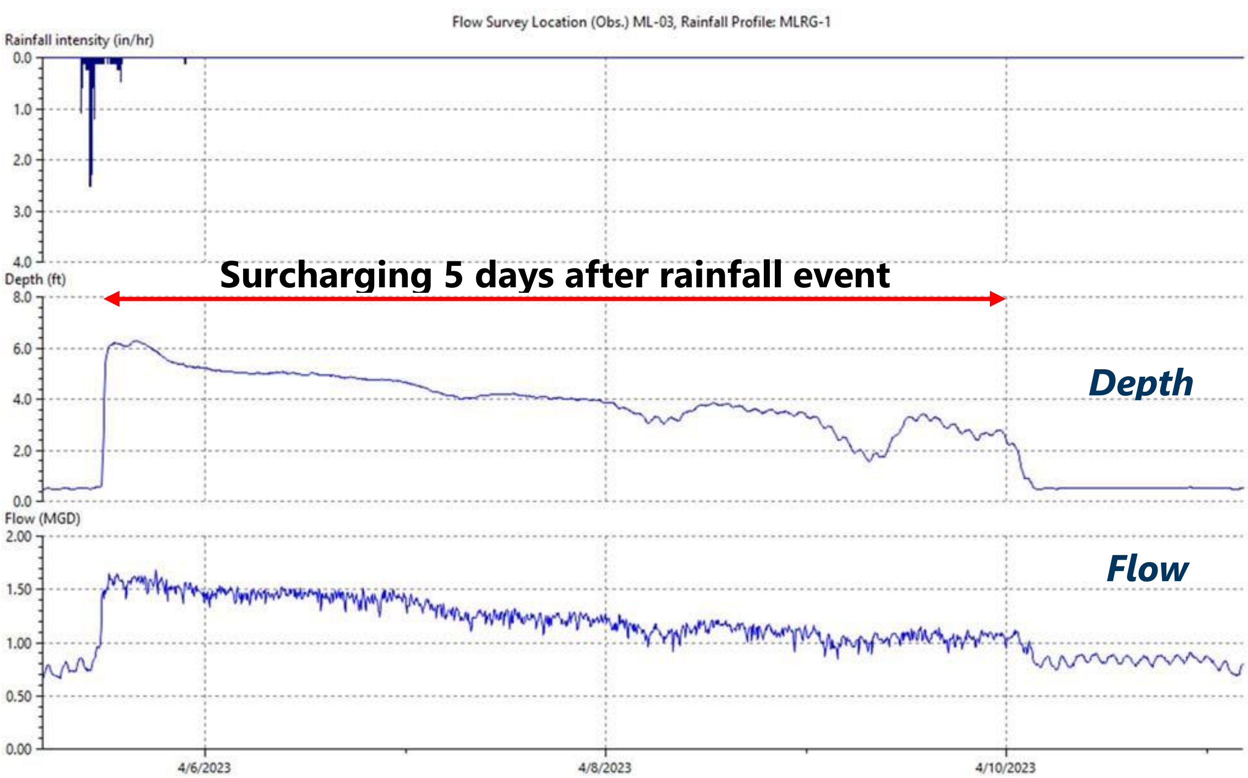


Figure 4-1. Prolonged Surcharging Due to Walco LS at ML-03

4.2 System Performance During Calibration Period

During the three months used for the calibration period, the model predicts that 47 manholes experienced surface flooding (SSO) and that approximately 16.2 million gallons of sewer were lost. Of the 16.2 million gallons (MG) of flooding projected during the flow monitoring period, approximately 14.9 MG, or 92 percent, are estimated to be caused by the backups caused by the Walco Lift Station. This does not mean that every model predicted SSO occurs in real life or that the SSO is at the exact location predicted by the model. However, the model provides a clear picture of the most significant hydraulic bottleneck in the system. Figure 4-2 shows the model predicted SSOs in pink and blue circles, with the pink circles meaning that the overflow was greater than 100,000 gallons.

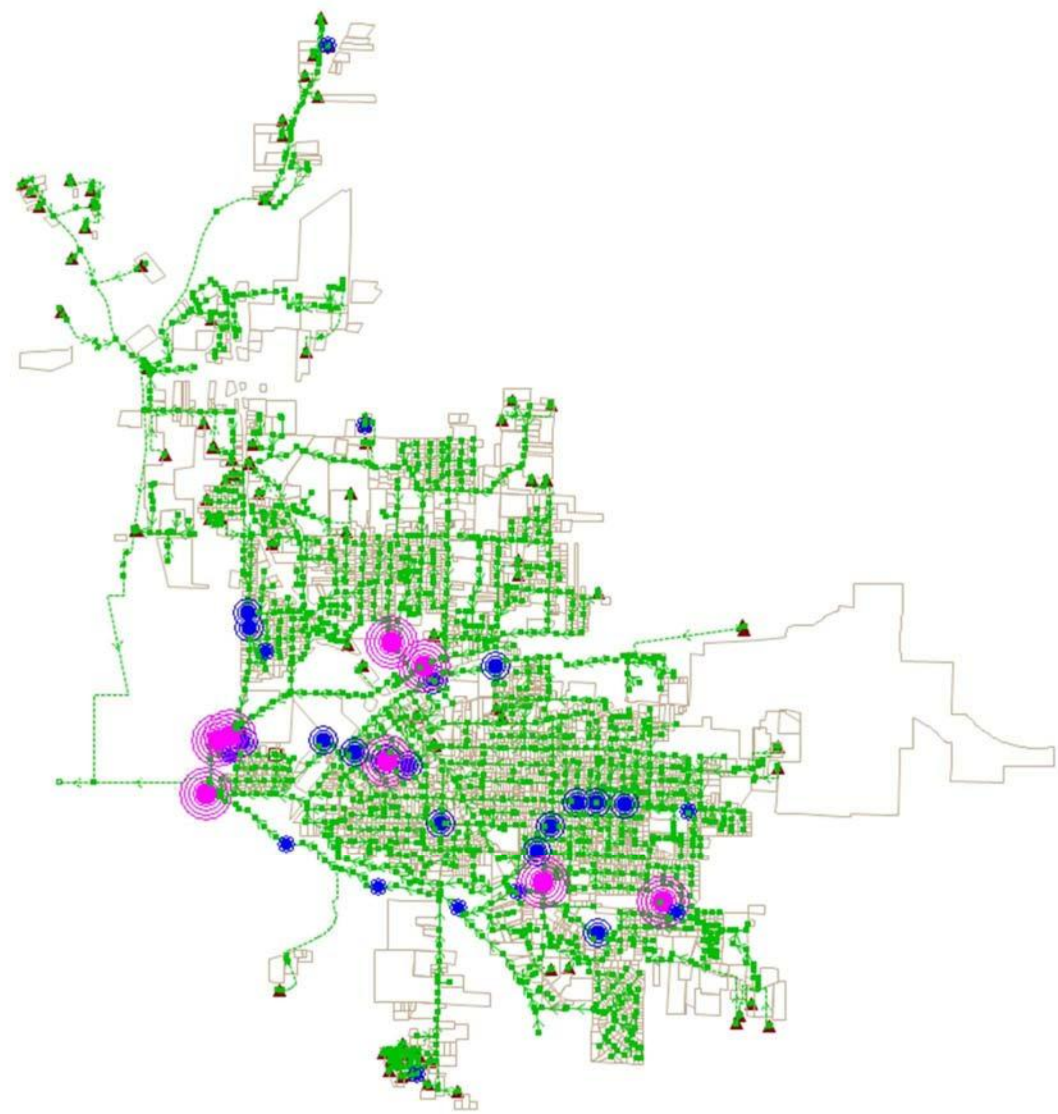


Figure 4-2. Model Predicted Overflows During Calibration Period

SECTION 5

CAPACITY ANALYSIS

5 Hydraulic Capacity Analysis

A hydraulic capacity analysis compares model-predicted flow rates to existing conveyance capacities and estimates the elevation of the hydraulic grade line (HGL) in the system, including the magnitudes of surcharging and flooding in the collection system. A hydraulic capacity analysis is performed by applying a simulated design storm to the hydraulic model to verify areas with sufficient capacity and identify deficiencies in the collection system. The 2-year, 6-hour design storm (3.11 inches of rainfall) was used to evaluate system capacity and develop the CIP recommendations listed in Chapter 5 of this report.

5.1 Design Storm Selection

Surcharging is the condition where the HGL in the sewer exceeds the pipe crown. Manholes are surcharging when the HGL is higher than the crown of the sewer connected to the manhole. Surface flooding occurs when the HGL reaches the ground surface, this is considered an SSO.

RJN reviewed the performance of the system under the 1-, 2-, and 5-year design storms of 1- and 6-hour durations. Table 5-1 presents the total flooding volume for each of the design storms under existing conditions. After discussions with Crist and the City, the 2-year, 6-hour design storm (3.11 inches) was selected to develop CIP recommendations for the City. The design storm distribution is from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14's methodology for the 1st Quartile, 50th percentile probability.

Table 5-1. Rainfall Sensitivity Analysis SSO Results

Model Predicted Sanitary Sewer Overflow Summary Per Design Storm						
Storm Duration	**1-Hour**			**6-Hour**		
Return Period, Years	**1-year**	**2-year**	**5-year**	**1-year**	**2-year**	**5-year**
Model SSO Volume, MG	0.95	1.22	1.70	2.75	3.69	5.63

The 2-year, 6-hour design storm with the NOAA Atlas 14, 1st Quartile, 50th percentile rainfall distribution was used to evaluate the capacity of the collection system. The selected distribution renders a front-ended storm, representing real-life storms more accurately than the bell-shaped distribution from the SCS Type II. The 2-year, 6-hour design storm has 3.11 inches of total rainfall and a peak 30-minute intensity of 1.06 inches per hour, as shown in Figure 5-1.

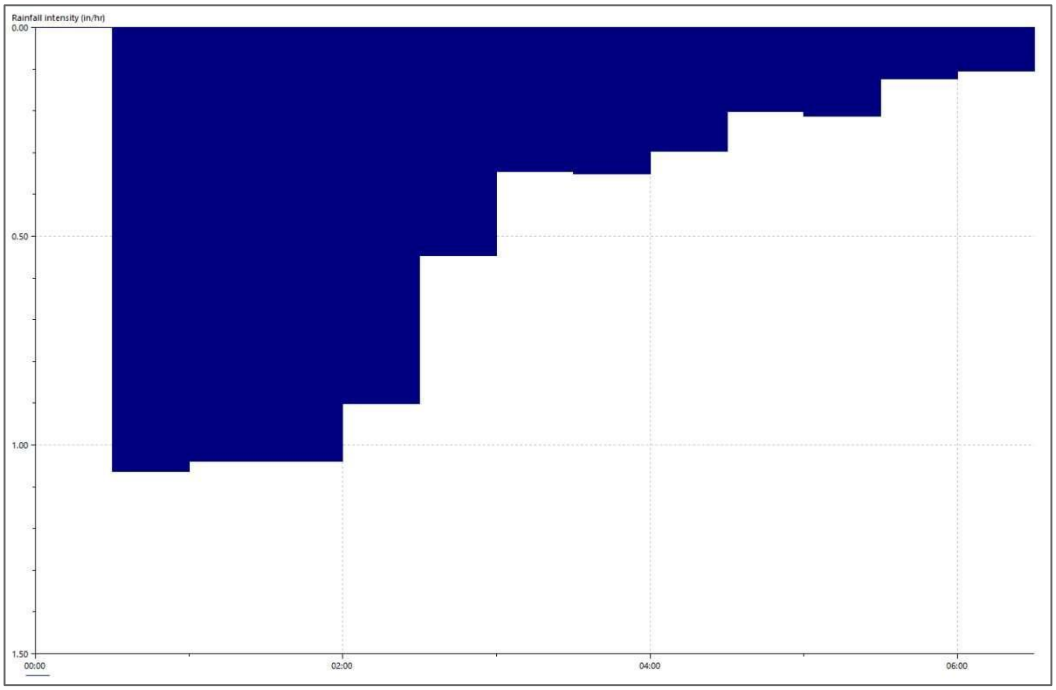


Figure 5-1. Hyetograph for 2-Year, 6-Hour Design Storm

5.2 Level of Service

The LOS defines an achievable performance capacity the City would like to provide to its customers. Defining LOS is paramount to developing a cost-effective capital improvement plan. Through a series of workshops with the City and Crist, the selected LOS was determined to be if there was a predicted SSO the level of surcharging in the sewer would be evaluated and contained to within 2-feet of the ground. This LOS would be used to identify when a capital improvement project was necessary and used in determining adequate sizing to resolve identified capacity issues.

5.3 Capacity Analysis Results

The 2-year, 6-hour design storm was applied to the existing system hydraulic model and evaluated for capacity deficiencies along the gravity sewer, lift stations, and forcemains. Table 5-2 presents the number of flooding manholes and total flooding volume during the 2-year, 6-hour design storm event for existing conditions.

Table 5-2. Projected Flooding Manholes and Volume During 2-Year, 6-Hour Design Storm

Model Predicted Sanitary Sewer Overflow Summary		
Scenario	**Flooding Volume (MG)**	**# of Manholes Flooding**
Existing Conditions	3.69	47

Figure 5-2 shows the model predicted flooding manholes in the existing system during the 2-year, 6-hour design storm event. Note that the model is unable to replicate any SSOs due to operation and maintenance reasons (e.g., localized blockage or structural failure), which are not a result of a hydraulic restriction.

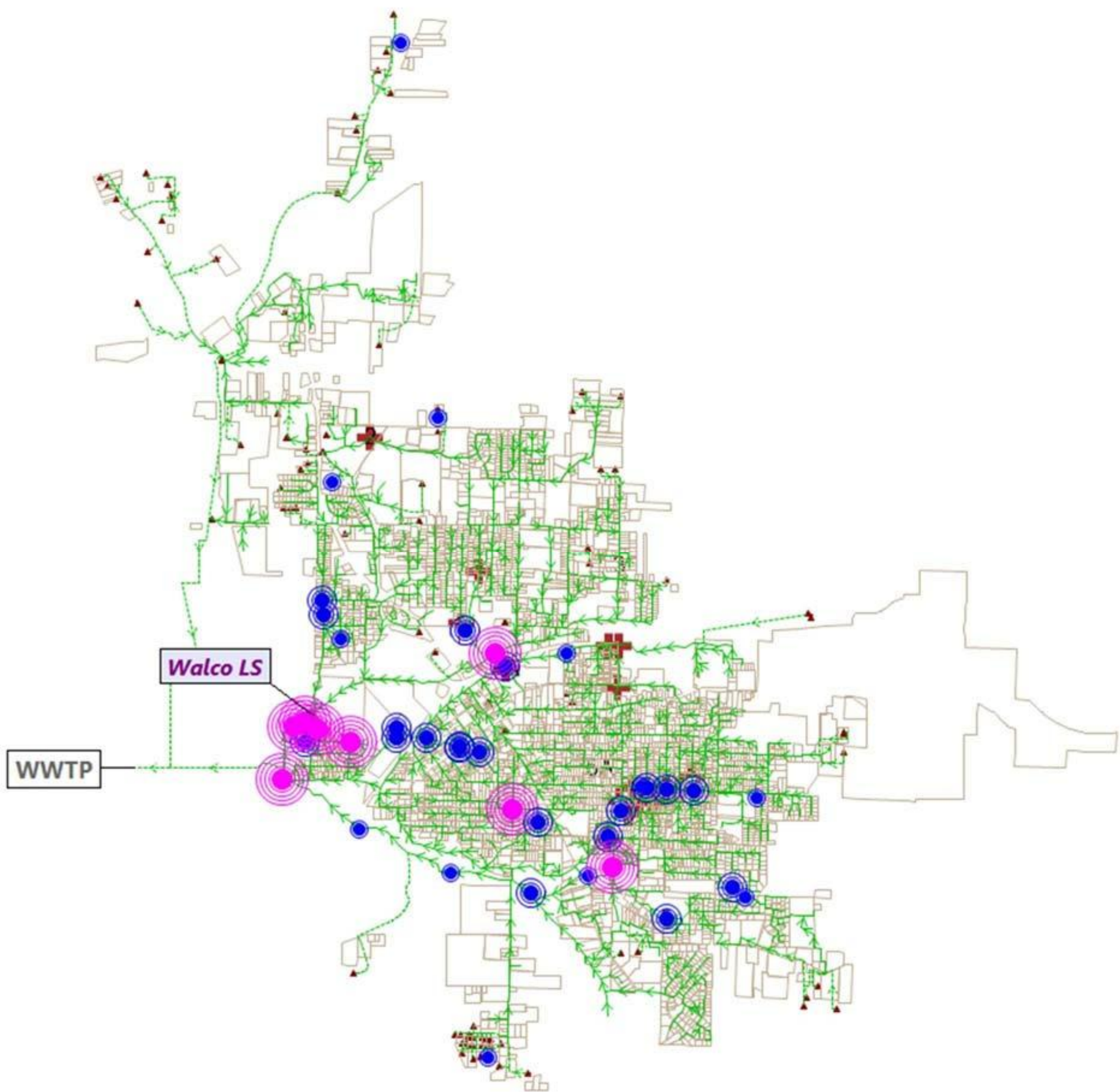


Figure 5-2. Model Predicted SSOs Under Existing Conditions During 2-Year, 6-Hour Design Storm

5.4 **WWTP Capacity Analysis**

The Malvern WWTP is permitted to discharge 5.908 MGD of treated wastewater per NPDES Permit No. AR0034126. Treatment facilities can experience a hydraulic overload if incoming flows exceed existing plant capacity. If flows to the WWTP are restricted to 6 MGD during the 2-year, 6-hour design storm, the WWTP would need approximately 1.32 million gallons of temporary wet weather storage as seen on the hydrograph in Figure 5-3.

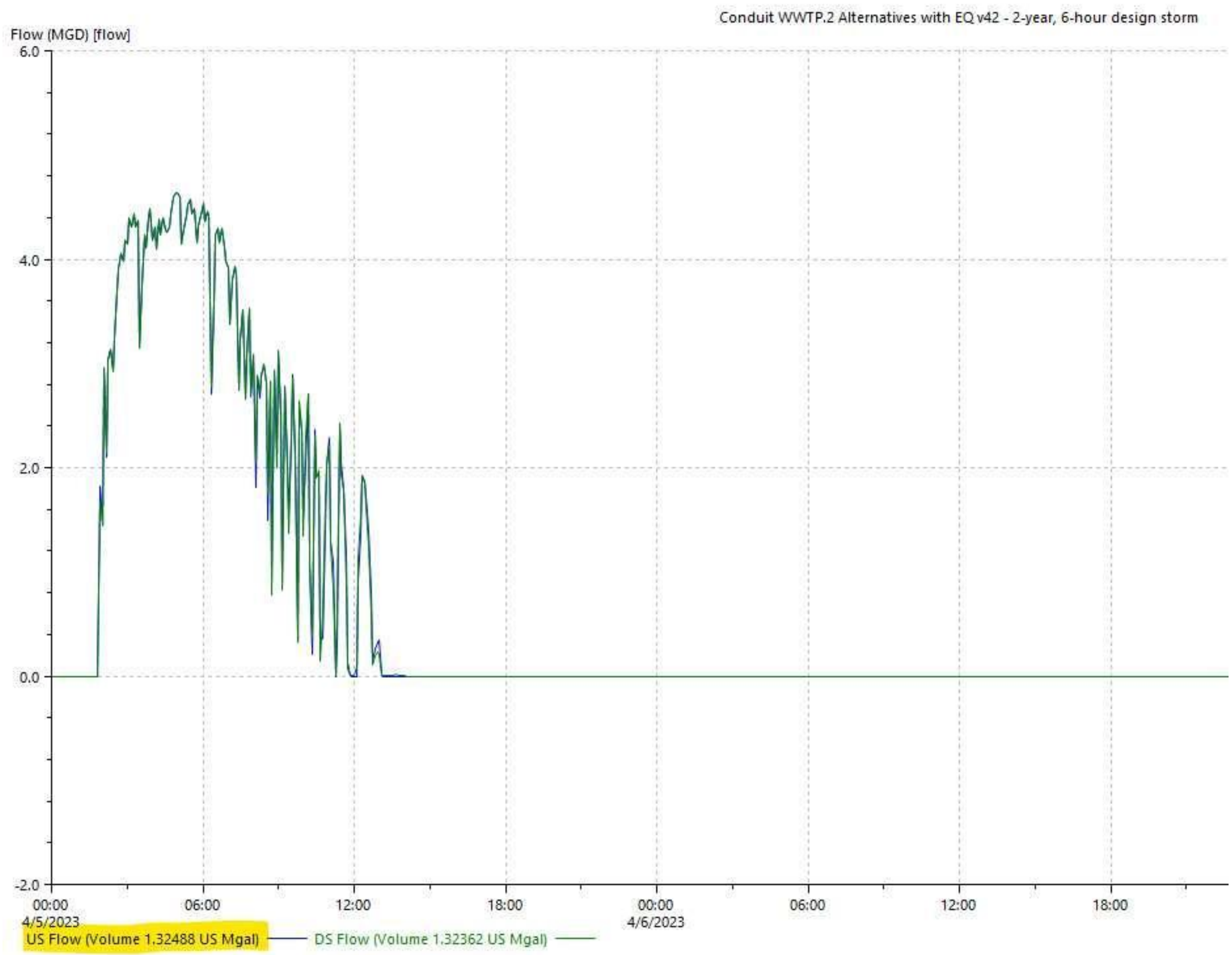


Figure 5-3. WWTP Design Storm Storage Capacity

SECTION 6

CAPITAL IMPROVEMENT PLAN

6 Capital Improvement Plan and Recommendations

Recommended capital improvement projects (CIPs) needed to address identified hydraulic capacity constraints are discussed in detail in this chapter. Hydraulic capacity constraints were identified when the selected LOS was not met during the 2-year, 6-hour design storm under existing conditions. Opinion of project costs (OPC) were included for each CIP recommendation and are presented in 2024 dollars.

The recommended solutions are a combination of infrastructure renewal projects, which will lower the overall I/I rates, paired with capacity enhancements of selected lift stations, forcemains, and sanitary sewers across the City to meet the LOS.

6.1 Methodology

Through the review of the results from the capacity analysis, alternative solutions were analyzed to resolve existing capacity restraints along gravity mains, lift stations, and forcemains to develop cost-effective CIPs.

Scenarios were iteratively analyzed that included I/I reductions in tandem with testing capacity enhancements. As the analysis progressed it became apparent that I/I abatement would significantly help the City reduce the volume and number of SSOs but would not be sufficient to address all the capacity deficiencies in certain portions of the system. Therefore, other capital projects were evaluated. In Table 6-1, the total model predicted volume of SSO is shown under the following scenario:

- existing conditions,
- existing conditions with improvements to the Walco LS,
- existing conditions with 30% I/I abatement upstream of Walco LS (no other improvements),
- existing conditions with improvements at Walco LS and 30% I/I abatement upstream of the lift station.

Table 6-1. Evaluating SSOs Under Different CIPs

Model Predicted Sanitary Sewer Overflow Summary During 2-Year, 6-Hour Design Storm				
Scenario	**Existing Conditions**	**Upsizing Walco LS** *(no I/I abatement)*	**30% I/I Abatement** *(no improvements at Walco LS)*	**30% I/I Abatement + Upsizing Walco LS**
Model SSO Volume, MG	**3.69**	**1.05**	**2.12**	**0.25**

The idea of evaluating these scenarios is to understand what the most effective capital project would be to pursue first. Per the results in the table above, upsizing the Walco Lift Station provides the most relief to the system. However, a combination of projects will be necessary to meet the LOS.

The list of capital improvement projects developed in this study to address capacity deficiencies was compared to the list of recommendations developed in the Sanitary Sewer Evaluation Study (SSES) Report, dated August 2024, to prevent providing redundant recommendations. The SSES report was done in tandem with the hydraulic model, and it addresses concerns in the collection system related to the structural condition of sewers and manholes. The estimated capital cost of the recommended SSES improvements is included in the CIP cost summary . The SSES improvement recommendations do not coincide with any of the below listed capacity-related CIPs, therefore, the SSES and capacity improvement recommendations remain independent from each other.

6.2 Capital Improvement Projects

The recommendations provided are all designed to contain the peak wet-weather flows resulting from the 2-year, 6-hour design storm under existing conditions (no growth was assumed).

Project A has two alternatives. Alternative 1 requires upsizing the Walco Lift Station at its current location and also requires upsizing portions of the interceptor leading towards the lift station from the south. Alternative 2 involves constructing a proposed lift station near Sullenberger Avenue and Acme Street to intercept the flows currently going to the Walco Lift Station. Alternative 2 will require less interceptor upsizing but involves acquiring property and easements for a proposed lift station and forcemain leading to the plant.

The predicted peak wet-weather flow of 10 MGD is significantly higher than what the city's wastewater treatment plant (WWTP) is permitted to discharge. As a result, implementing either alternative for Project A will require a flow equalization basin (FEB) at the WWTP to provide temporary storage of wet-weather flows.

6.2.1 Project A, Alternative 1

Project A, Alternative Package 1 requires upsizing the Walco Lift Station at its current location and upsizing interceptors leading towards the lift station.

P.A.1.1 - Project A, Alternative 1, Phase 1: Upsizing Walco LS and Forcemain

- The Walco Lift Station would remain at its current location.
- A proposed 10 MGD lift station would be necessary to convey the peak flows.
- Approximately 6,100 linear feet (LF) of existing 16-inch forcemain would need to be upsized to a 24-inch forcemain.

Note that Walco LS is currently located within a flood zone. The lift station should be moved for reasons outside of capacity.

Figure 6-1 shows an overview of the project. The estimated OPC of **P.A.1.1** is **$11,555,000**

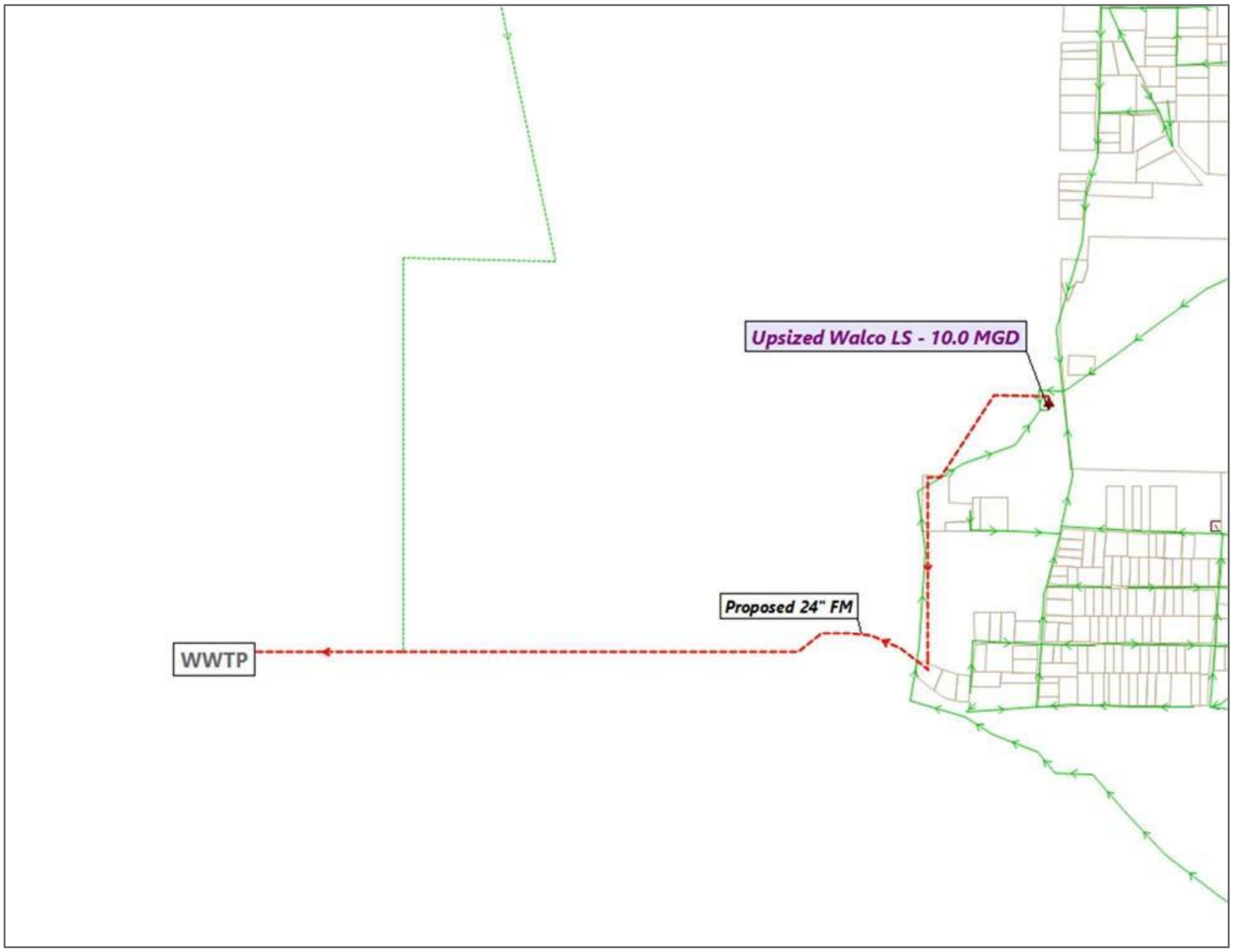


Figure 6-1. P.A.1.1 – Upsizing Walco LS and Forcemain

P.A.1.2 - Project A, Alternative 1, Phase 2: Upsizing Southern Interceptor & Flow Diversion

From downstream to upstream:

- **From Waco LS to MH0716** - Upsize 50 LF of existing 24-inch sewer to a proposed 42-inch sewer.
- **From MH0716 to MH0910** - Upsize 3,290 LF of the existing southern interceptor from existing 18- and 21-inch sewer to a proposed 30-inch sewer.
- **From MH0910 to MH0883** - Re-route flows with approximately 800 feet of proposed 18-inch sewer from basin ML-05 to the proposed 30-inch southern interceptor.
- **From MH0729 to MH0729** - Upsize 3,490 LF of the existing 12-inch sewer to a proposed 18-inch sewer from MH0883 to MH0729.

Figure 6-2 shows an overview of the project. The estimated OPC of **P.A.1.2** is **$4,707,300**

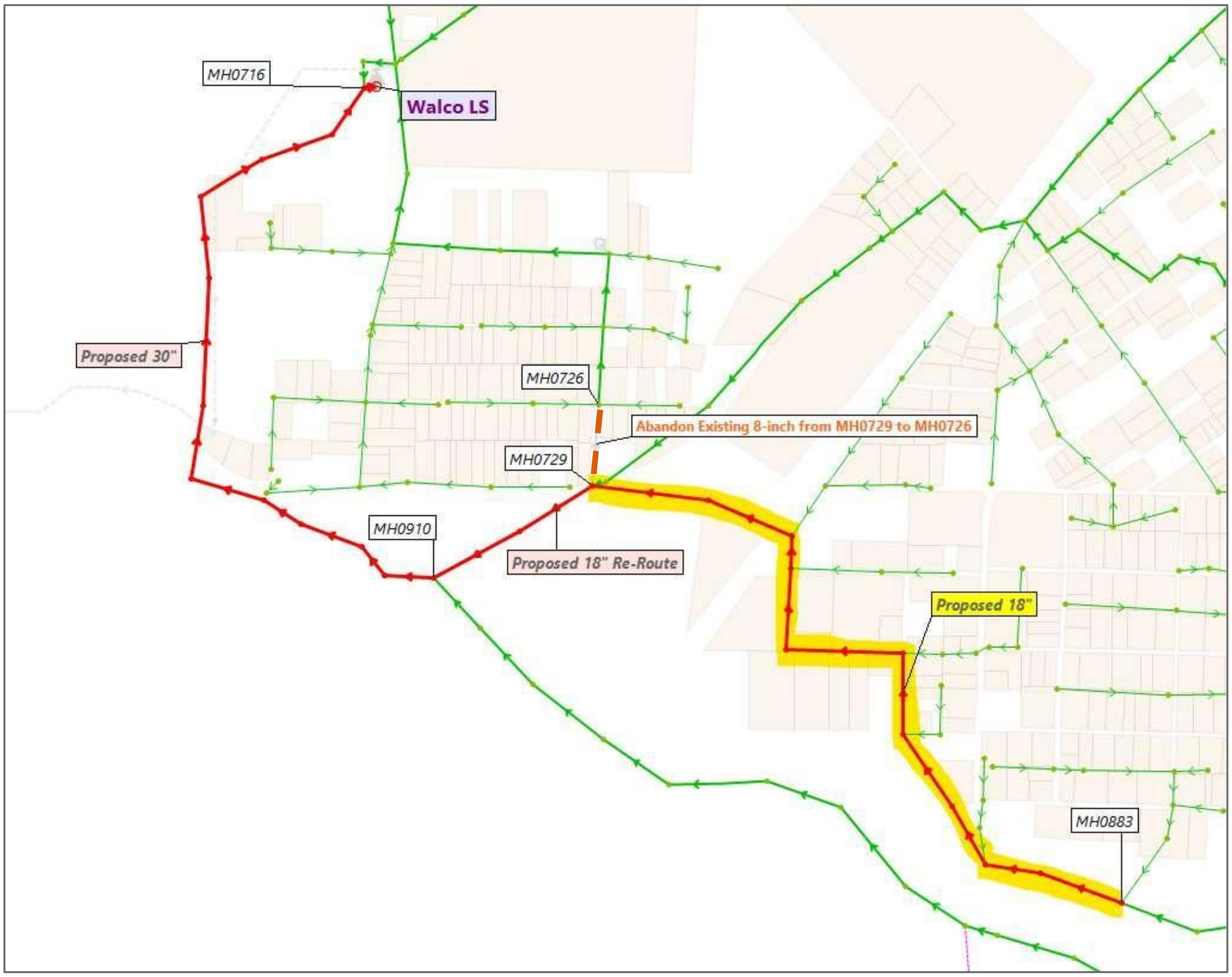


Figure 6-2. P.A.1.2 – Upsizing Southern Interceptor & Diverting Flows from Basin 5

6.2.2 Project A, Alternative 2

Project A, Alternative Package 2, requires constructing a proposed lift station near Sullenberger Avenue and Acme Street to intercept the flows currently going to the Walco Lift Station. This alternative would require less interceptor upsizing but involves acquiring property and easements for a proposed lift station and forcemain leading to the plant.

P.A.2.1 - Project A, Alternative 2, Phase 1: Proposed Lift Station and Forcemain near Sullenberger Avenue and Acme Street

- Proposed 7.05 MGD lift station at Sullenberger Avenue and Acme Street
- Approx. 6,200 LF of proposed 20-inch forcemain to WWTP

Figure 6-3 shows an overview of the project. The estimated OPC of **P.A.2.1** is **$8,522,000**

Note that Walco LS would remain active and receive a peak flow of 2.95 MGD. Per Crist Engineers, additional upgrades will be needed at the Walco Rd LS including proposed pumps and a proposed force main to the WWTP due to condition. The estimated costs of these upgrades are included in this CIP but are subject to revisions after a comprehensive evaluation of the Walco Rd LS is performed.

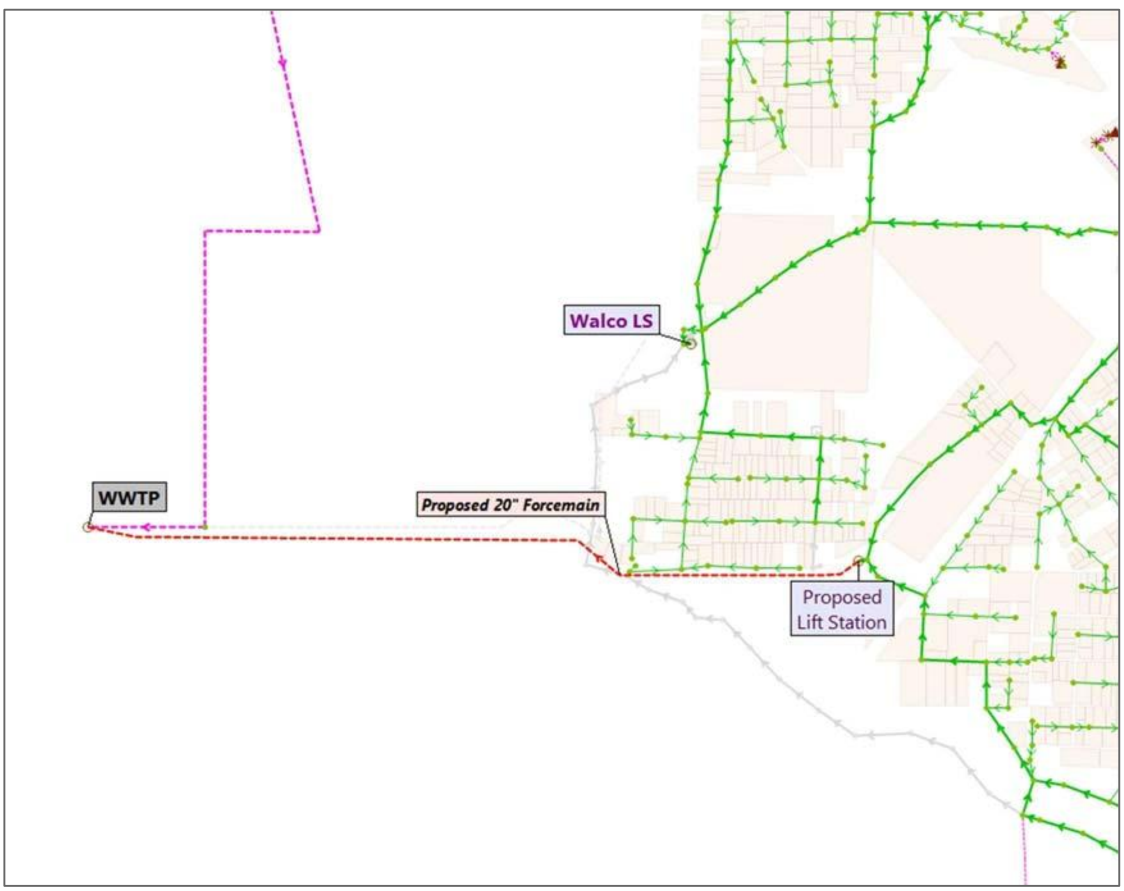


Figure 6-3. P.A.2.1 –Proposed Lift Station and Forcemain

P.A.2.2 - Project A, Alternative 2, Phase 2: Upsizing 12" North of Chatman Creek

From downstream to upstream:

- **From Proposed LS to MH0857** - Upsize 2,590 LF of existing 12-inch sewer to a proposed 30-inch sewer.
- **From MH0857 to MH0883** - Upsize 610 LF of the existing 12-inch sewer to a proposed 18-inch sewer.
- **From MH0883 to MH0902 –** Re-route flows from the existing 15-inch interceptor via a proposed 24-inch sewer crossing Chatman Creek
- **From MH 0716 to MH0902 –** Abandon existing 21- inch and 18-inch interceptors.

Figure 6-4 shows an overview of the project. The estimated OPC of **P.A.2.2** is **$2,962,050**.

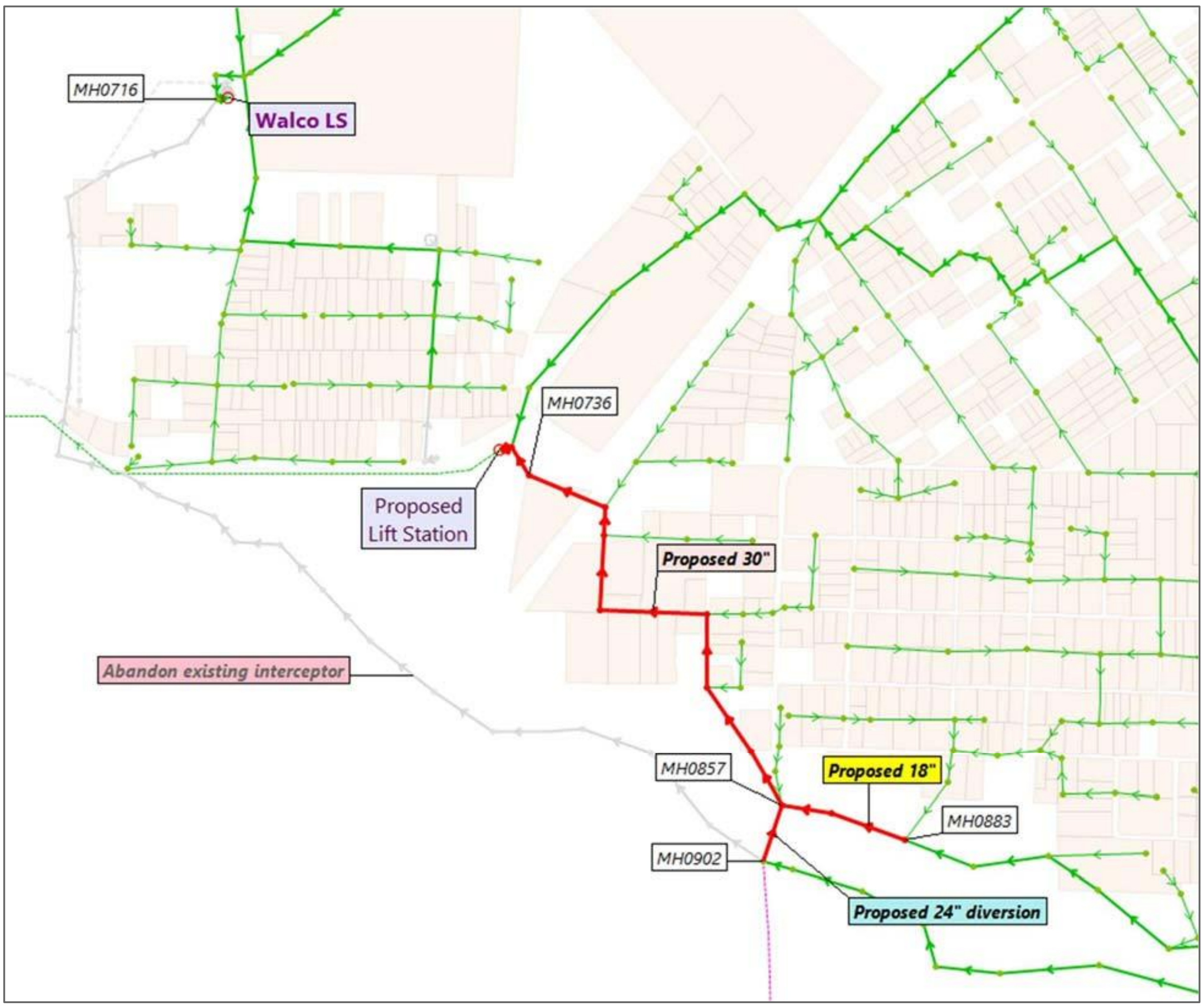


Figure 6-4. P.A.2.2 – Upsizing 12" North of Chatman Creek

P.A.3.1 – Project A, Phase 3: Flow Equalization System

Project A, Phase 3 requires re-purposing the existing abandoned pond 1 at the WWTP as the proposed FEB, modifying the existing influent junction box, constructing a proposed 24-inch drain, EQ return pump station, and force main.

Figure 6-4A shows an overview of the project. The estimated OPC of P.A.3.1 is **$1,862,250**

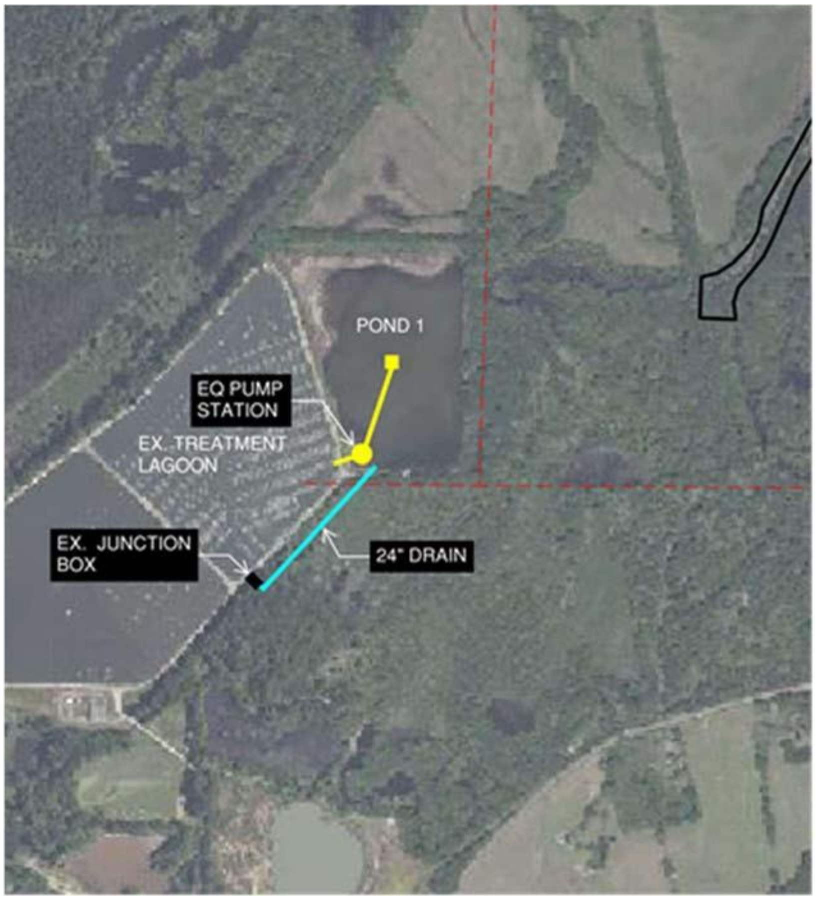


Figure 6-5A. P.A.3 - Flow Equalization Basin Overview

6.3 Project B – Upsizing Northern Interceptor

From downstream to upstream:

- **From MH0716 to MH0701 –** Upsize 250 LF of existing 18-inch sewer to a proposed 30-inch sewer.
- **From MH0701 to MH0774 –** Upsize 1,540 LF of existing 15-inch sewer to a proposed 24-inch sewer.
- **From MH0774 to MH0761 –** Upsize 3,490 LF of existing12-inch sewer to a proposed 18-inch sewer.

Figure 6-6 shows an overview of the project. The estimated OPC of **Project B** is **$3,091,075**

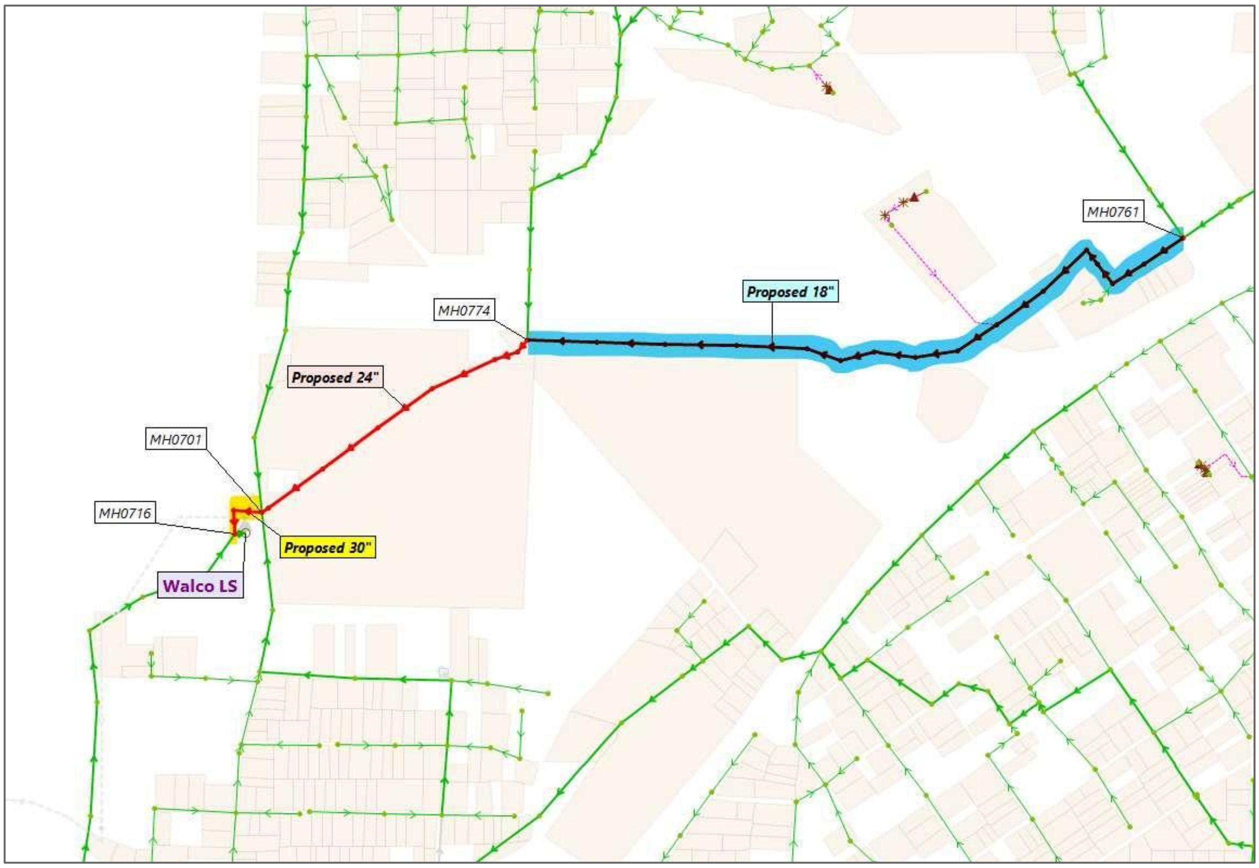


Figure 6-6. Project B – Upsizing Northern Interceptor

6.4 Project C – Burris Road Sewer Upsizing Behind Train Tracks

From downstream to upstream:

- **From MH0729 to MH0751 –** Upsize 2,400 LF of existing 12-inch sewer to a proposed 18-inch sewer at 0.25 percent slope or higher.
- **From MH0701 to MH0774 –** Upsize 1,810 LF of existing 8-inch sewer to a proposed 15-inch sewer at 0.25 percent slope or higher.
- **From MH0774 to MH0761 –** Upsize 1,800 LF of existing 8-inch sewer to a proposed 12-inch sewer at 0.40 percent slope or higher.

Figure 6-7 shows an overview of the project. The estimated OPC of **Project C** is **$3,412,110**.

Note that at the downstream end of this project, at MH0729, it is recommended to divert the flows to a proposed lift station or a proposed sewer diversion, as listed out in the two alternatives for Project A.

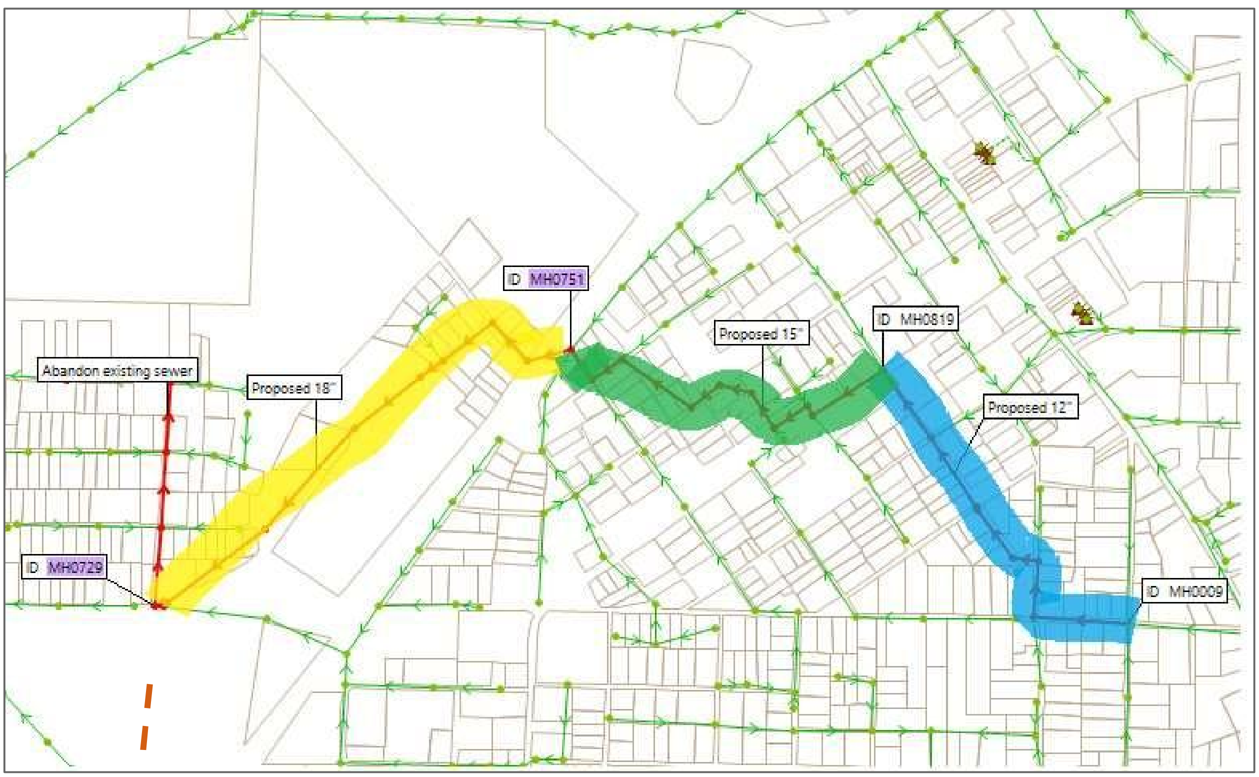


Figure 6-7. Project C – Burris Road Sewer Upsizing Behind Train Tracks

6.5 Project D – Sewer Upsizing Along Mill Street

From downstream to upstream:

- **Add Wier at MH0243** – To make the 12-inch going west the primary flow path, add weir plate to the 15-inch going south. The weir crest should be 1-1/4′ above the invert elevation of the 15-inch going south.
- **From MH0016 to MH0243** - Upsize 4,800 LF of existing 8- and 10-inch sewer to a proposed 15-inch sewer.
- **From MH0243 to MH0130** - Upsize 1,000 LF of existing 8-inch sewer to a proposed 12-inch sewer.

Figure 6-8 shows an overview of the project. The estimated OPC of **Project D** is **$2,815,475**.

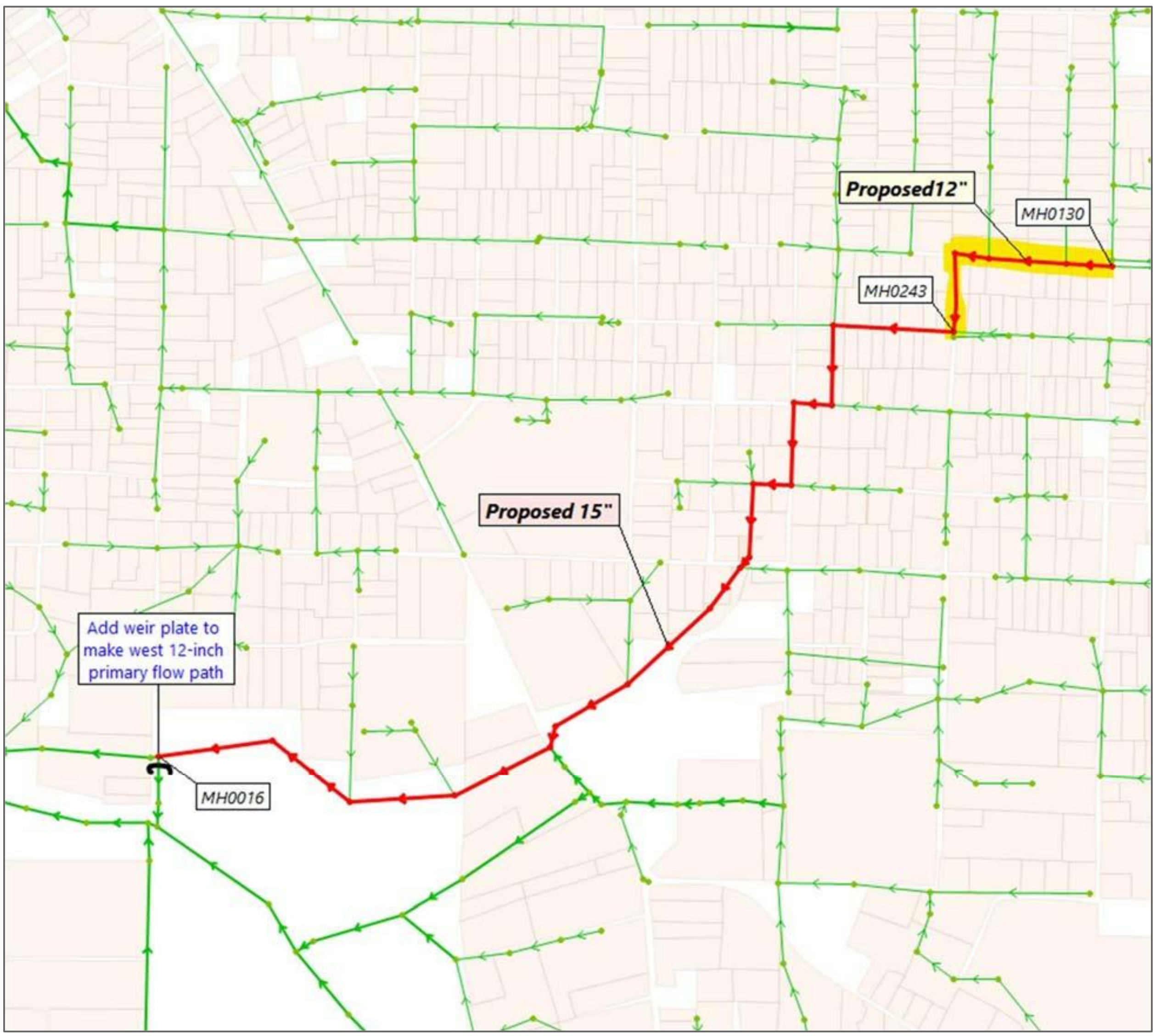


Figure 6-8. Project D – Sewer Upsizing Along Mill Street

6.6 Project E – Upsizing Sewer Upstream of Sulphur Springs Road

From downstream to upstream:

- **From MH0310A to MH0312** - Upsize 840 LF of existing 8-inch sewer to a proposed 15-inch sewer.
- **From MH0312 to MH0331** – Pipe burst 3,270 LF of existing 8-inch sewer to a 10-inch sewer.

Figure 6-9 shows an overview of the project. The estimated OPC of **Project E** is **$1,265,550**.

Figure 6-9. Project E – Upsizing Sewer Upstream of Sulphur Springs Road

6.7 Project F – Pipe Burst at Wilson Street & Park Avenue

From downstream to upstream:

- **From MH0329 to MH0394** – Pipe burst 1,070 LF of existing 6-inch sewer to an 8-inch sewer.

Figure 6-10 shows an overview of the project. The estimated OPC of **Project F** is **$379,340**.

Figure 6-10. Project F – Pipe Burst at Wilson Street & Park Avenue

6.8 Project G – Pipe Burst Along Sullenberger Avenue

From downstream to upstream:

- **From MH0146 to MH0379** – Pipe burst 1,160 LF of existing 6-inch sewer to an 8-inch sewer.

Figure 6-11 shows an overview of the project. The estimated OPC of **Project G** is **$371,020**

Figure 6-11. Project G – Pipe Burst Along Sullenberger Avenue

6.9 Capital Improvement Project Summary

Table 6-2 below provides a summarization of the estimated OPCs for the capital improvement plan recommendations. The itemized OPCs per project are provided in Appendix C.

Table 6-2. Capital Improvement Projects OPCs

CIP Summary			
#	**Project**	**Project Description**	**Capital Cost**
1	A	Proposed 7 MGD Pump Station	$5,531,500
2	A	Proposed 20" Force Main	$2,991,300
3	A	Chatman Creek Sewer Diversion & Upsizing	$2,962,050
4	A	Flow Equalization System	$1,862,250
5	W	Walco Rd PS Evaluation	$20,000
6	S	Sewer System Rehabilitation	$3,010,000
7	W	Walco Rd PS Proposed 20" Force Main	$3,111,600
8	W	Walco Rd PS Rehabilitation	$487,500
9	B	North Sewer Interceptor Upsizing	$3,091,075
10	C	Burris Rd Sewer Upsizing	$3,412,110
11	D	Mill St Sewer Upsizing	$2,815,475
12	E	Sulphur Springs Rd Sewer Upsizing	$1,265,550
13	F	Wilson St & Park Ave Sewer Pipe Burst	$379,340
14	G	Sullenberger Ave Sewer Pipe Burst	$371,020
		TOTAL	**$31,310,770**

SECTION 7

GLOSSARY

rjn group
Engineering infrastructure for tomorrow

GLOSSARY

Average Dry-Weather Flow (ADWF) – Dry-weather and low-groundwater flow exclusive of dry-weather and high-groundwater (i.e., peak infiltration) and wet-weather flow (i.e., inflow) during an extended period (i.e., seven to 14 days). This includes base flow and permanent infiltration only.

Capital Improvements Project (CIP) – Identified wastewater collection system capital projects in regard to this project.

Dry-Weather Flow (DWF) – All flow in a sewer, which includes sanitary flow and permanent groundwater infiltration, minus flow caused directly by rainfall. This is measured during a period of extended dry weather (i.e., seven to 14 days) and seasonally high groundwater.

Hydraulic Grade Line (HGL) – The surface or profile of water flowing in an open channel or a pipe flowing partially full. If a pipe is under pressure, the hydraulic grade line is that level water would rise to in a small, vertical tube connected to the pipe.

Hydrograph – A graph showing depth, velocity, flow, and rain measurements with respect to time.

Infiltration – Water other than sanitary sewer wastewater that enters a sewer system due to rain, from sources such as pipe joints, sewer line defects, defective manhole walls, benches, and pipe seals.

Inflow – Water other than sanitary sewer wastewater that enters a sewer system from sources such as roof downspouts, foundation drains, yard drains, area drains, manhole covers, defective services, and cross-connections between the storm and sanitary sewers.

InfoWorks Integrated Catchment Modeling (ICM) – An integrated hydraulic modeling platform created by Innovyze used for this project.

Million Gallons (MG) – Unit of volume.

Million Gallons per Day (MGD) – Unit of measure for flow rate.

National Oceanic and Atmospheric Administration (NOAA) – This is an American government scientific agency within the United States Department of Commerce focused on conditions of the oceans and the atmosphere.

Permanent Groundwater Infiltration (GWI) – Measured during the average dry-weather flow period. The average of the low, nighttime flows (i.e., usually midnight to 6 A.M.) per day for the same period, minus significant industrial or commercial nighttime flows.

Sanitary Sewer Overflow (SSO) – An event when surcharged sanitary sewer flow reaches a height above the top of a sanitary sewer structure and excess sanitary sewer flow is discharged out of the sanitary sewer system as a bypass.

Wet-Weather Flow (WWF) – The highest daily flow during and immediately after a significant storm event. It includes sanitary flow, infiltration, and inflow.

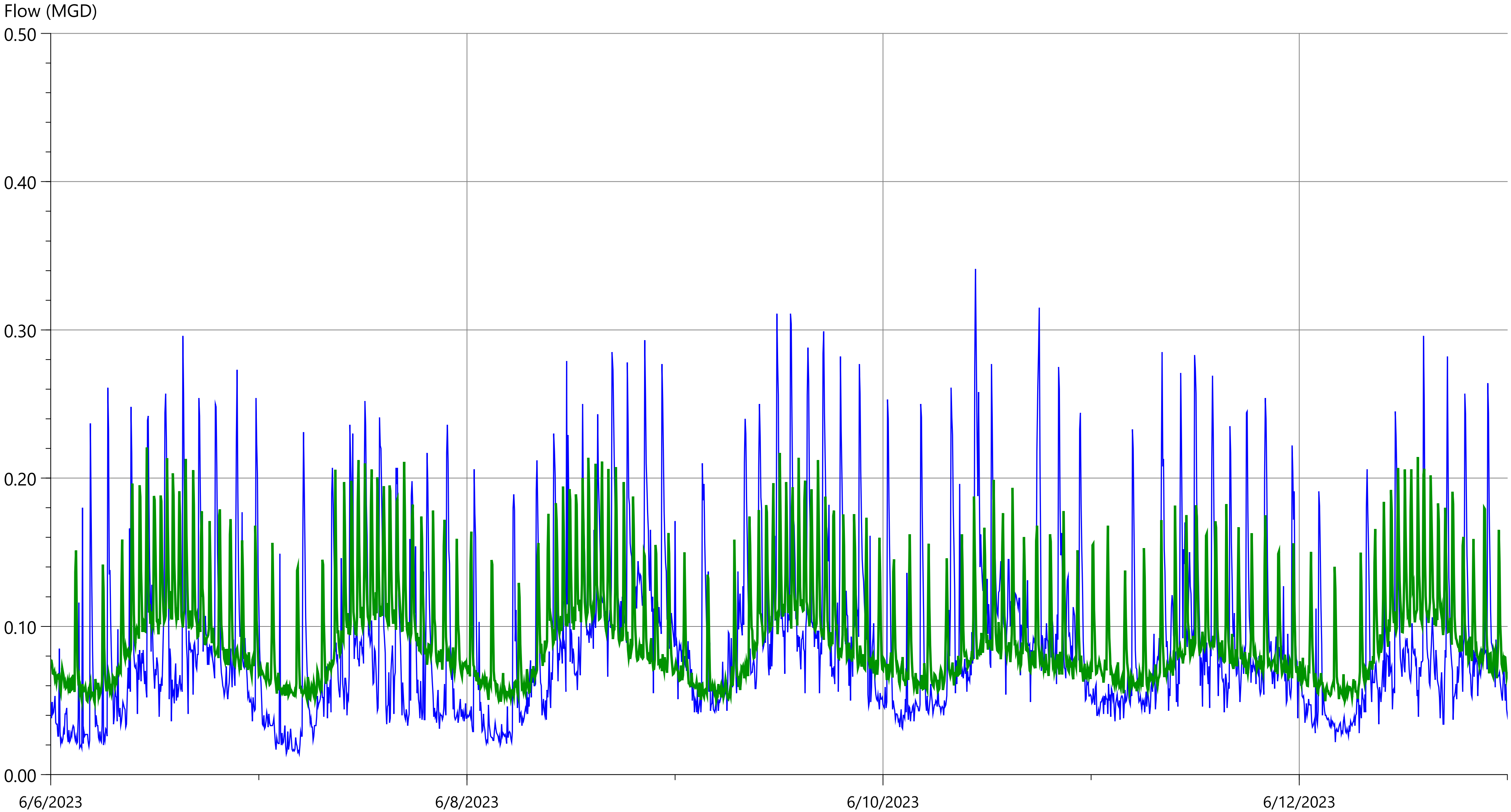
Wastewater Treatment Plant (WWTP) – Biological, chemical, and physical process facility for removing contaminants from wastewater.

APPENDIX A

rjngroup
Engineering infrastructure for tomorrow

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:07:10 PM) Page 1 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>DWF Calibration>DWF Calibration 6/6-6/13>DWF (10/4/2024 2:22:06 PM)

Flow Survey Location (Obs.) ML-01, Model Location (Pred.) D/S MH1526A.1



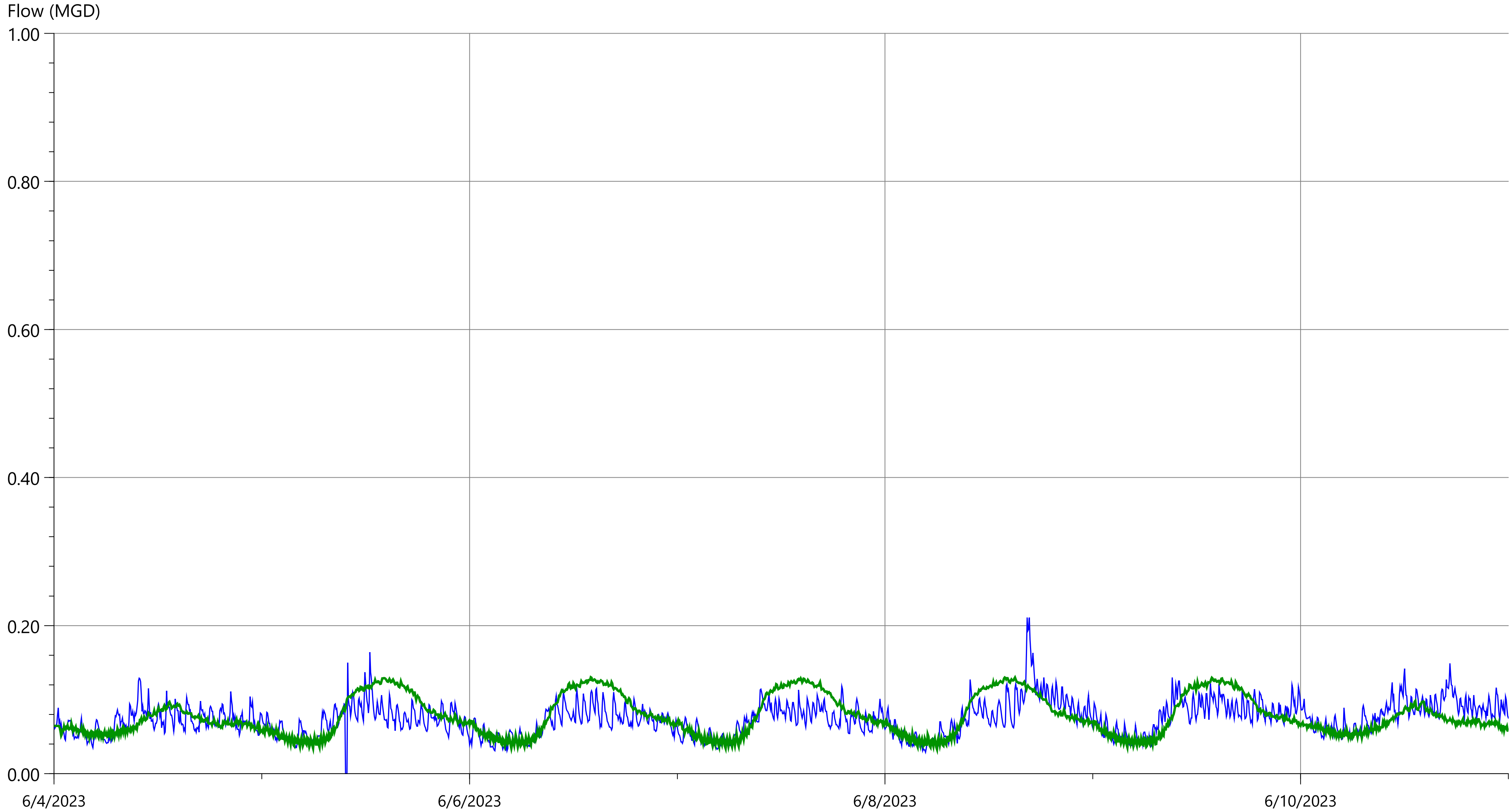
	Flow		
	Min (MGD)	Max (MGD)	Volume (US Mgal)
Observed	0.014	0.341	0.624
DWF Calibration 6/6-6/13>DWF	0.049	0.221	0.654

Observed / Predicted Report (Custom graph) - Hydrographs 2023 DWF Calibration

Powered by InfoWorks

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:24:05 PM) Page 2 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>DWF Calibration>DWF Calibration 6/4-6/11!>DWF (10/4/2024 3:16:00 PM)

Flow Survey Location (Obs.) ML-02, Model Location (Pred.) D/S MH1371.1



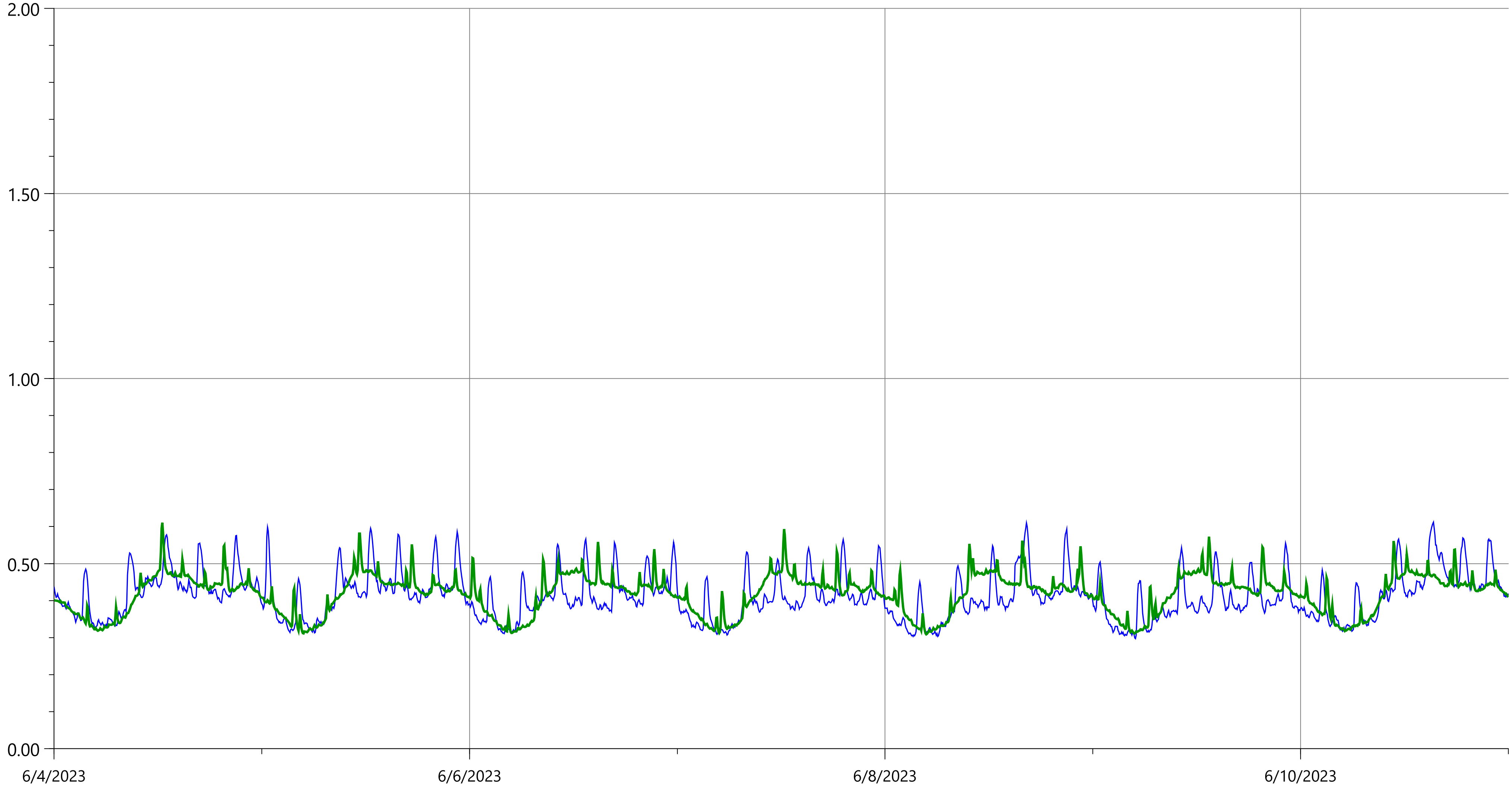
	Flow		
	Min (MGD)	Max (MGD)	Volume (US Mgal)
Observed	0.000	0.211	0.522
DWF Calibration 6/4-6/11!>DWF	0.033	0.130	0.545

Observed / Predicted Report (Custom graph) - Hydrographs 2023 DWF Calibration

Powered by InfoWorks

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:24:05 PM) Page 3 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>DWF Calibration>DWF Calibration 6/4-6/11!>DWF (10/4/2024 3:16:00 PM)

Flow Survey Location (Obs.) ML-03, Model Location (Pred.) D/S MH0959A.1



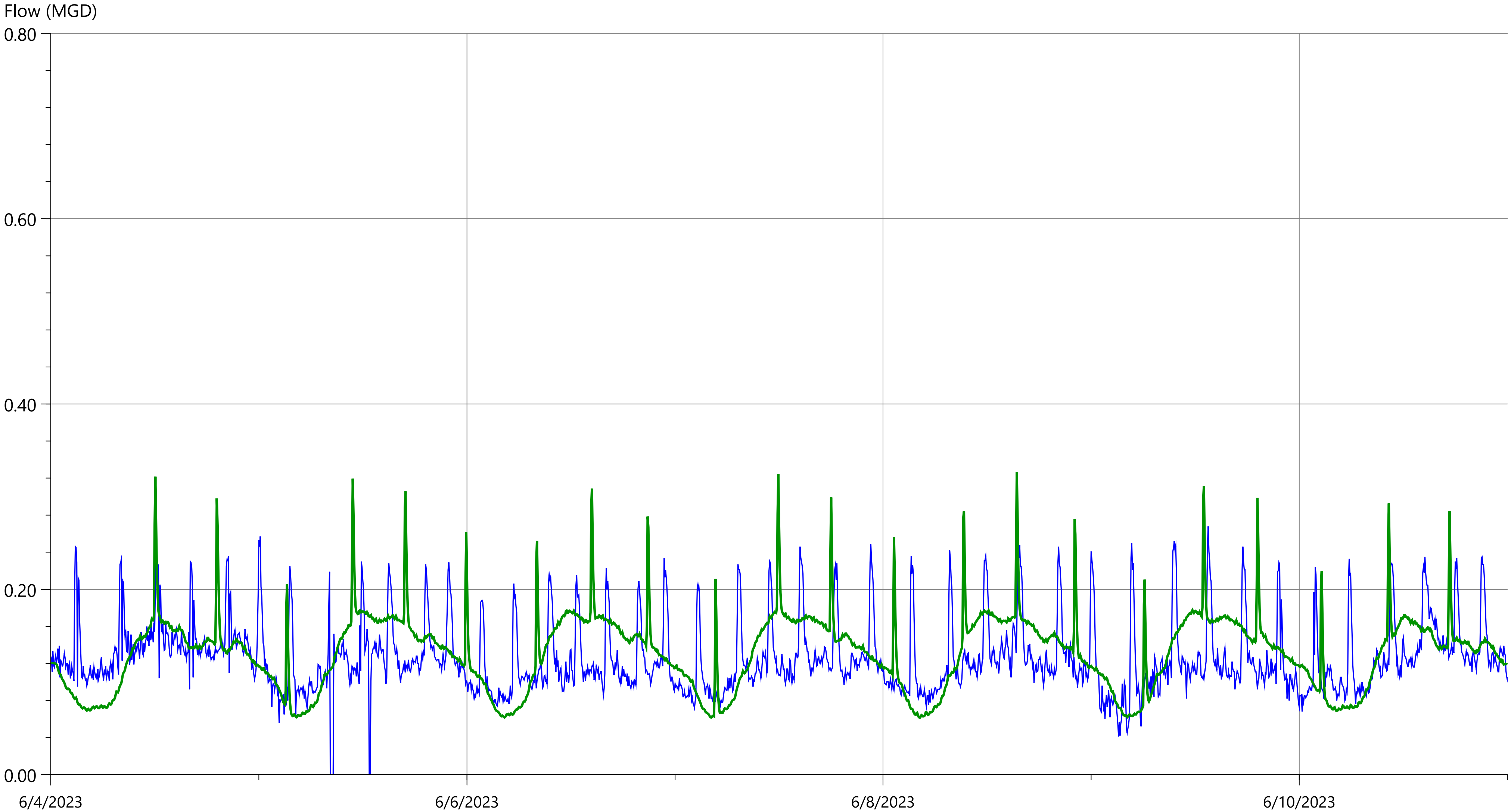
	Flow		
	Min (MGD)	Max (MGD)	Volume (US Mgal)
Observed	0.297	0.612	2.879
DWF Calibration 6/4-6/11!>DWF	0.309	0.611	2.927

Observed / Predicted Report (Custom graph) - Hydrographs 2023 DWF Calibration

Powered by InfoWorks

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:24:05 PM) Page 4 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>DWF Calibration>DWF Calibration 6/4-6/11!>DWF (10/4/2024 3:16:00 PM)

Flow Survey Location (Obs.) ML-03A, Model Location (Pred.) D/S MH0005.1



	Flow		
	Min (MGD)	Max (MGD)	Volume (US Mgal)
Observed	0.000	0.268	0.882
DWF Calibration 6/4-6/11!>DWF	0.062	0.327	0.927

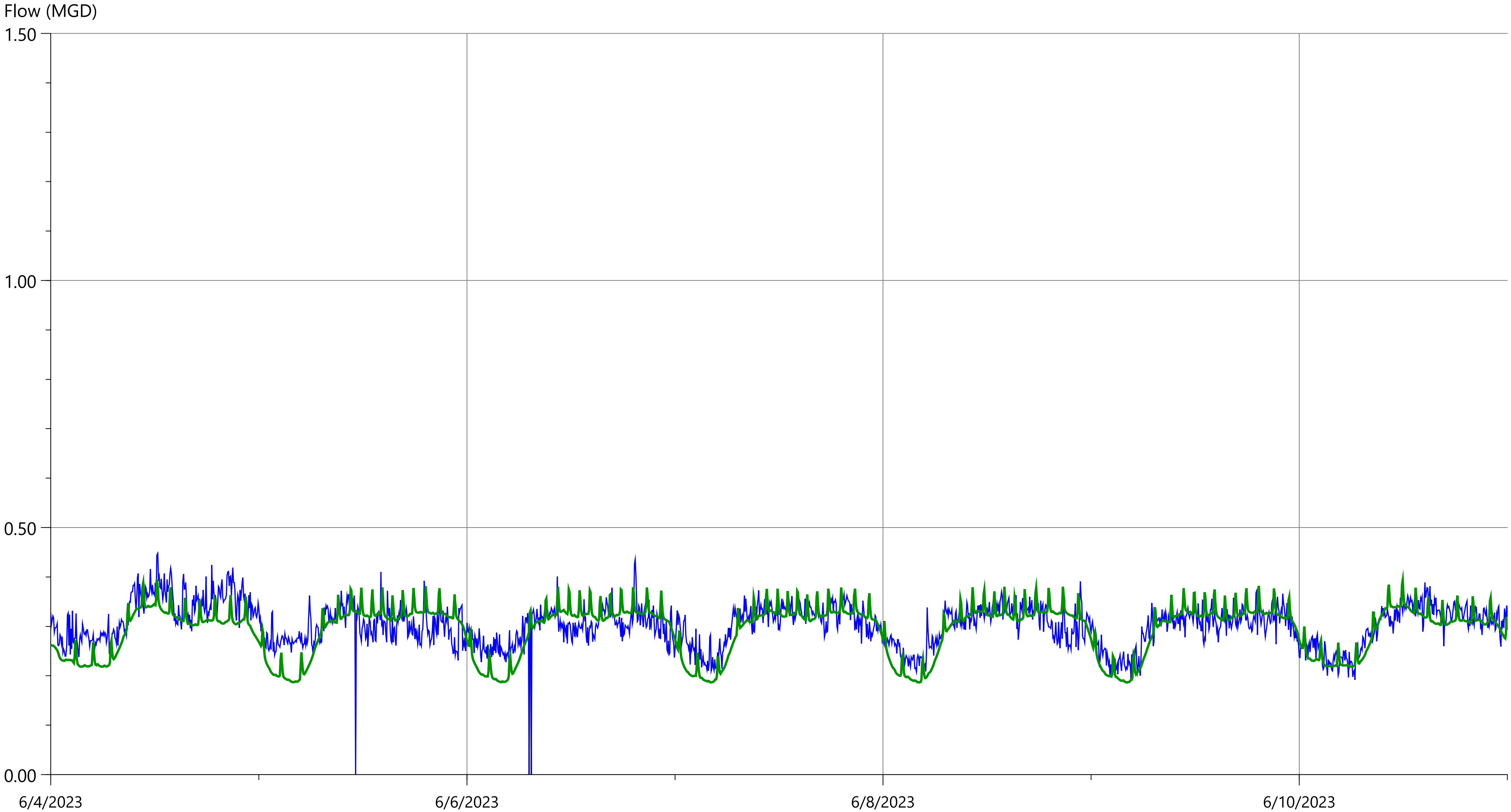
Observed / Predicted Report (Custom graph) - Hydrographs 2023 DWF Calibration

Powered by InfoWorks

Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)

Sim: >City of Malvern 2023>DWF Calibration>DWF Calibration 6/4-6/11!>DWF (10/4/2024 3:16:00 PM)

Flow Survey Location (Obs.) ML-04, Model Location (Pred.) D/S MH0297.1



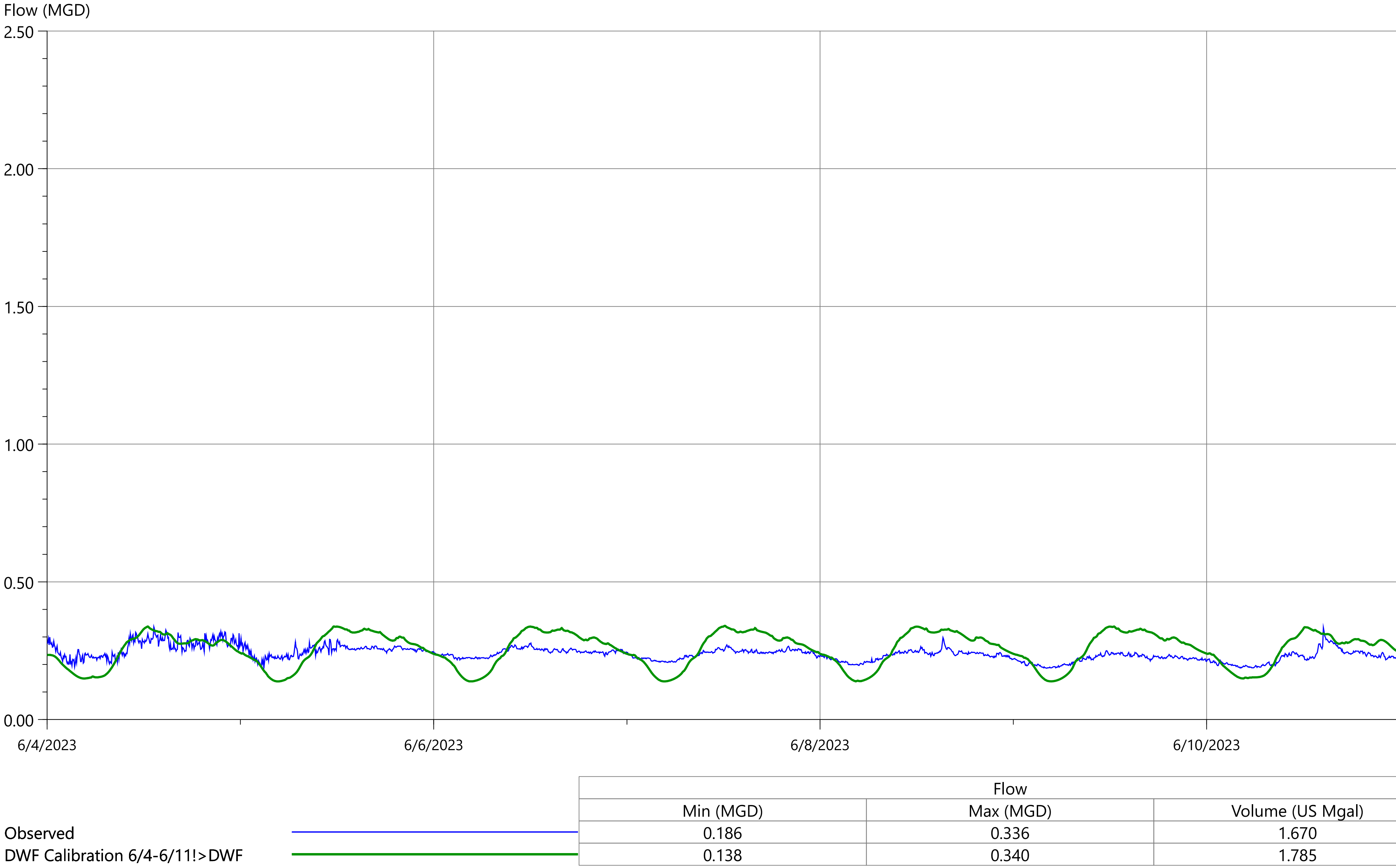
	Flow		
	Min (MGD)	Max (MGD)	Volume (US Mgal)
Observed	0.000	0.448	2.120
DWF Calibration 6/4-6/11!>DWF	0.187	0.394	2.053

Observed / Predicted Report (Custom graph) - Hydrographs 2023 DWF Calibration

Powered by InfoWorks

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:24:05 PM) Page 6 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>DWF Calibration>DWF Calibration 6/4-6/11!>DWF (10/4/2024 3:16:00 PM)

Flow Survey Location (Obs.) ML-05, Model Location (Pred.) D/S MH0718.1



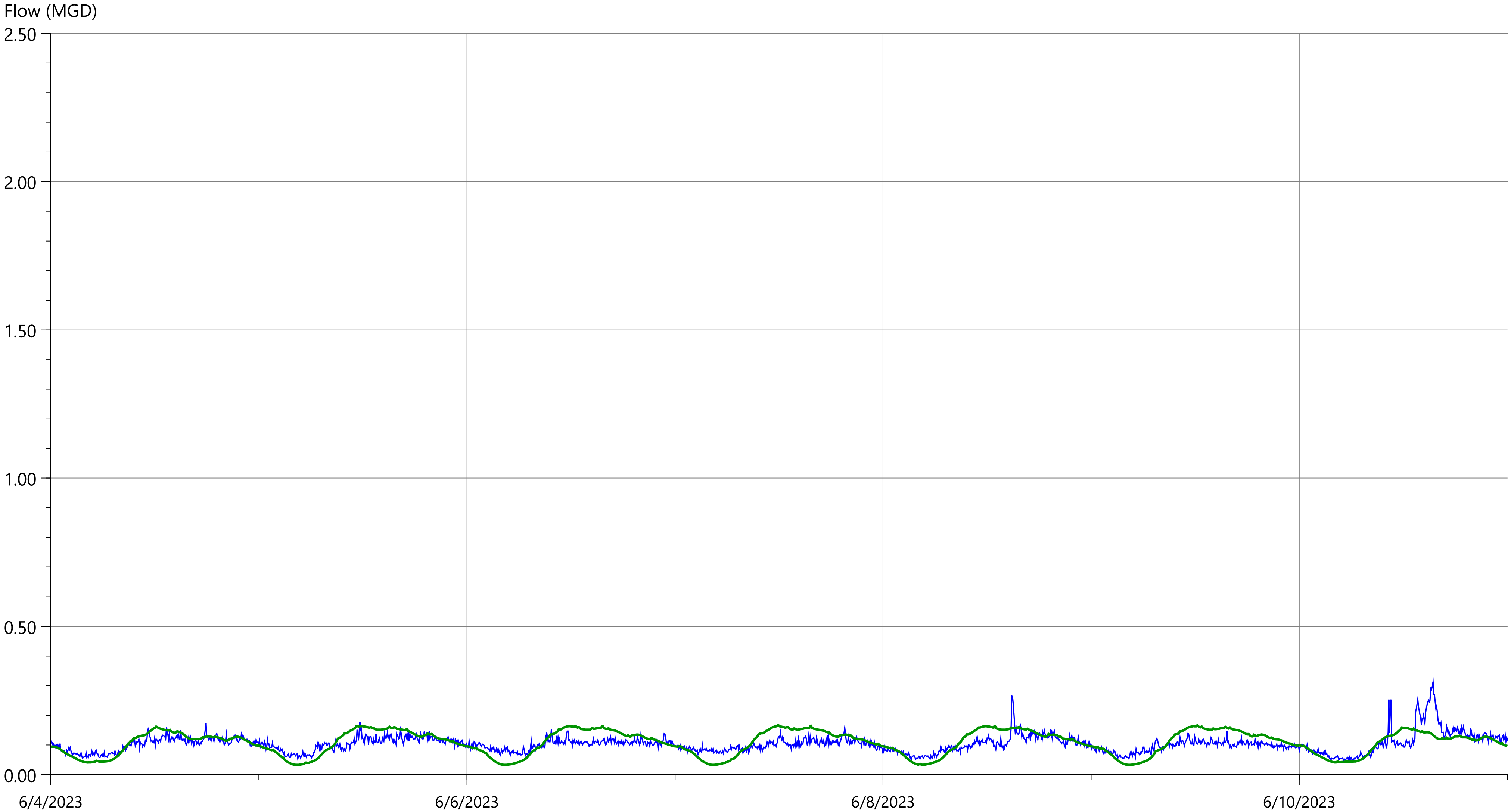
	Flow		
	Min (MGD)	Max (MGD)	Volume (US Mgal)
Observed	0.186	0.336	1.670
DWF Calibration 6/4-6/11!>DWF	0.138	0.340	1.785

Observed / Predicted Report (Custom graph) - Hydrographs 2023 DWF Calibration

Powered by InfoWorks

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:24:05 PM) Page 7 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>DWF Calibration>DWF Calibration 6/4-6/11!>DWF (10/4/2024 3:16:00 PM)

Flow Survey Location (Obs.) ML-05A, Model Location (Pred.) D/S MH0746.1

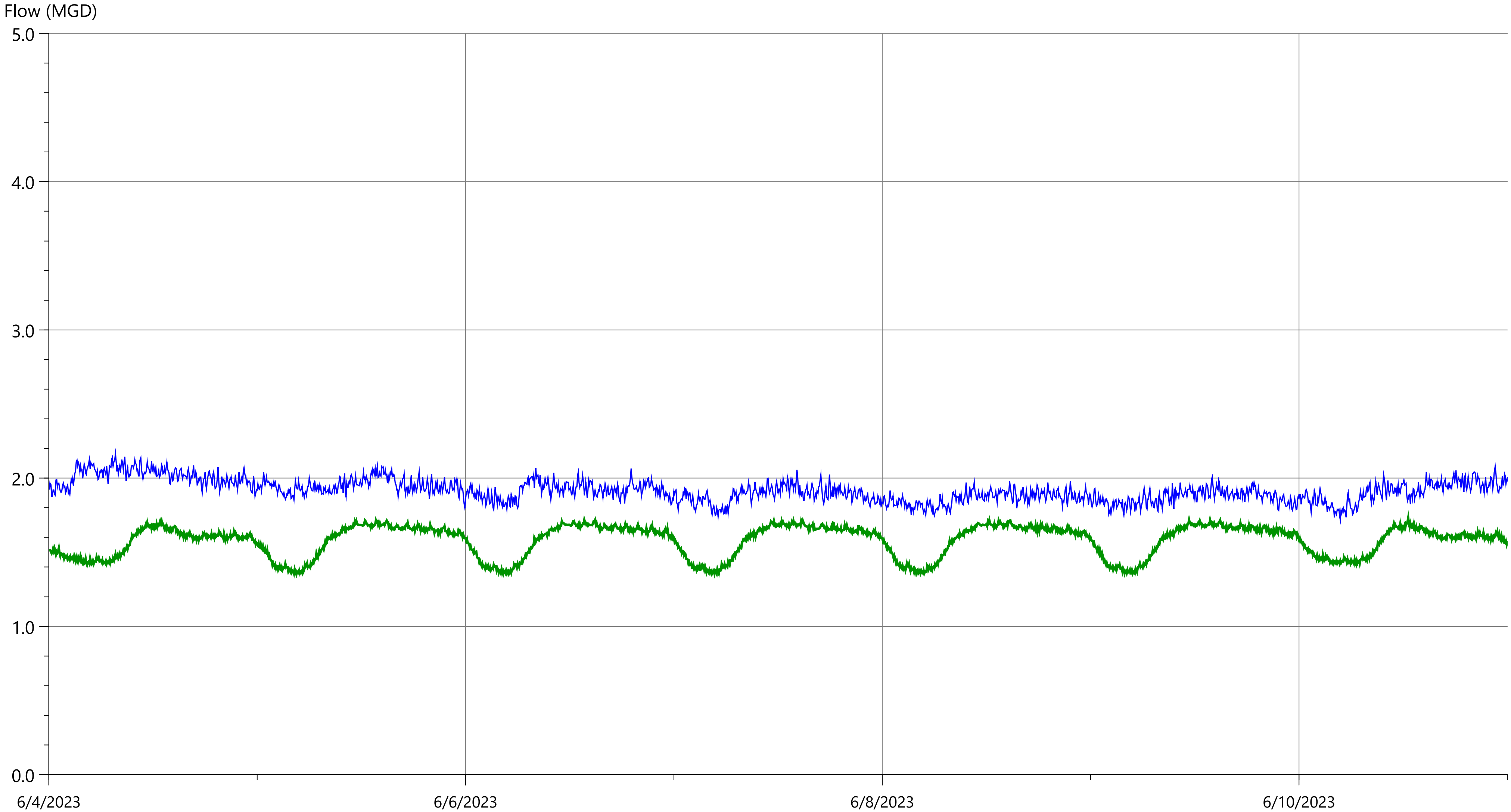


	Flow		
	Min (MGD)	Max (MGD)	Volume (US Mgal)
Observed	0.048	0.312	0.721
DWF Calibration 6/4-6/11!>DWF	0.033	0.167	0.759

Observed / Predicted Report (Custom graph) - Hydrographs 2023 DWF Calibration

Powered by InfoWorks

Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>DWF Calibration>DWF Calibration 6/4-6/11!>DWF (10/4/2024 3:16:00 PM)



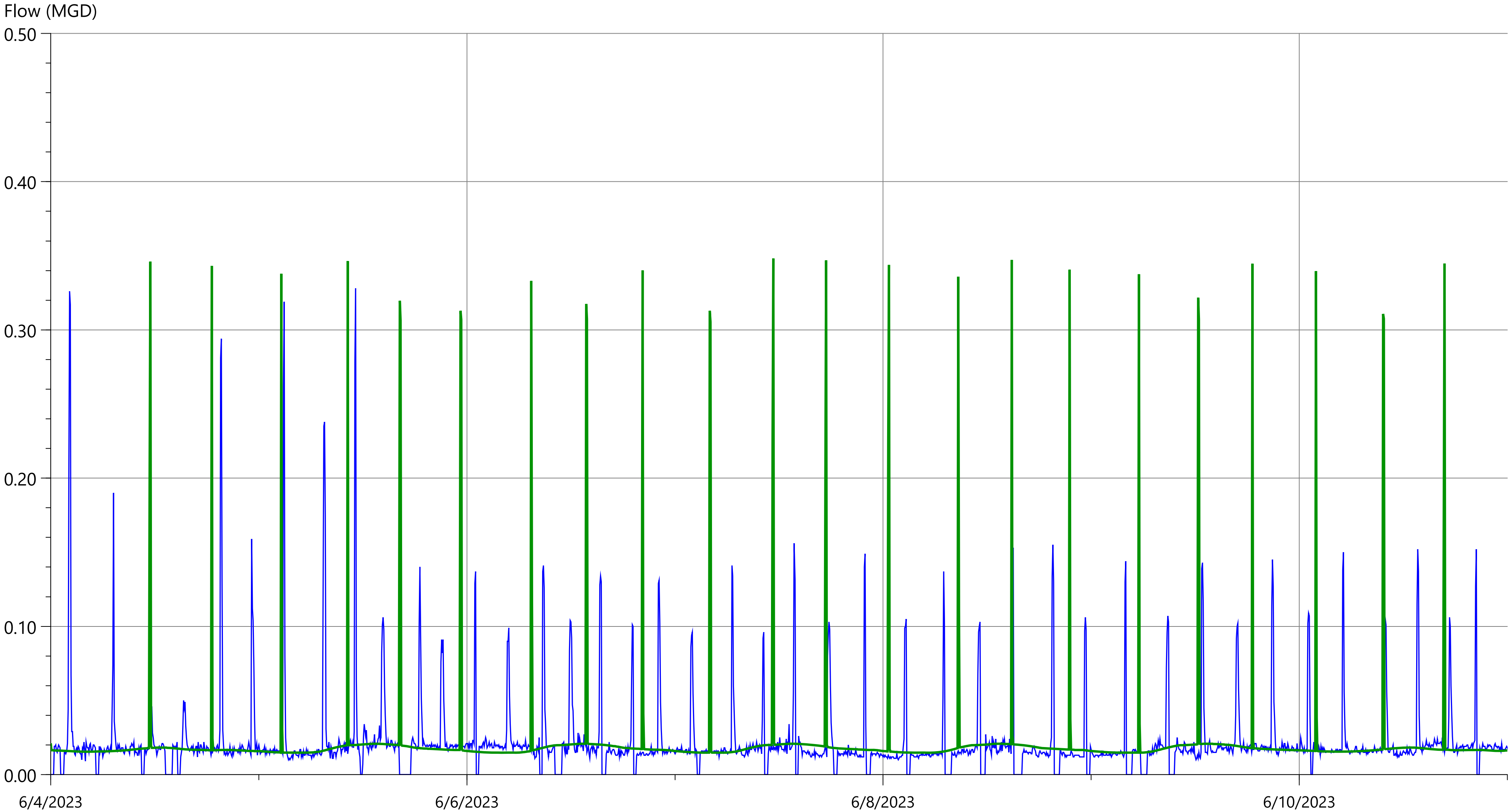
	Flow		
	Min (MGD)	Max (MGD)	Volume (US Mgal)
Observed	1.717	2.165	13.413
DWF Calibration 6/4-6/11!>DWF	1.351	1.731	11.052

Observed / Predicted Report (Custom graph) - Hydrographs 2023 DWF Calibration

Powered by InfoWorks

Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>DWF Calibration>DWF Calibration 6/4-6/11!>DWF (10/4/2024 3:16:00 PM)

Flow Survey Location (Obs.) ML-P, Model Location (Pred.) U/S MH1150.1



	Flow		
	Min (MGD)	Max (MGD)	Volume (US Mgal)
Observed	0.000	0.332	0.159
DWF Calibration 6/4-6/11!>DWF	0.015	0.348	0.156

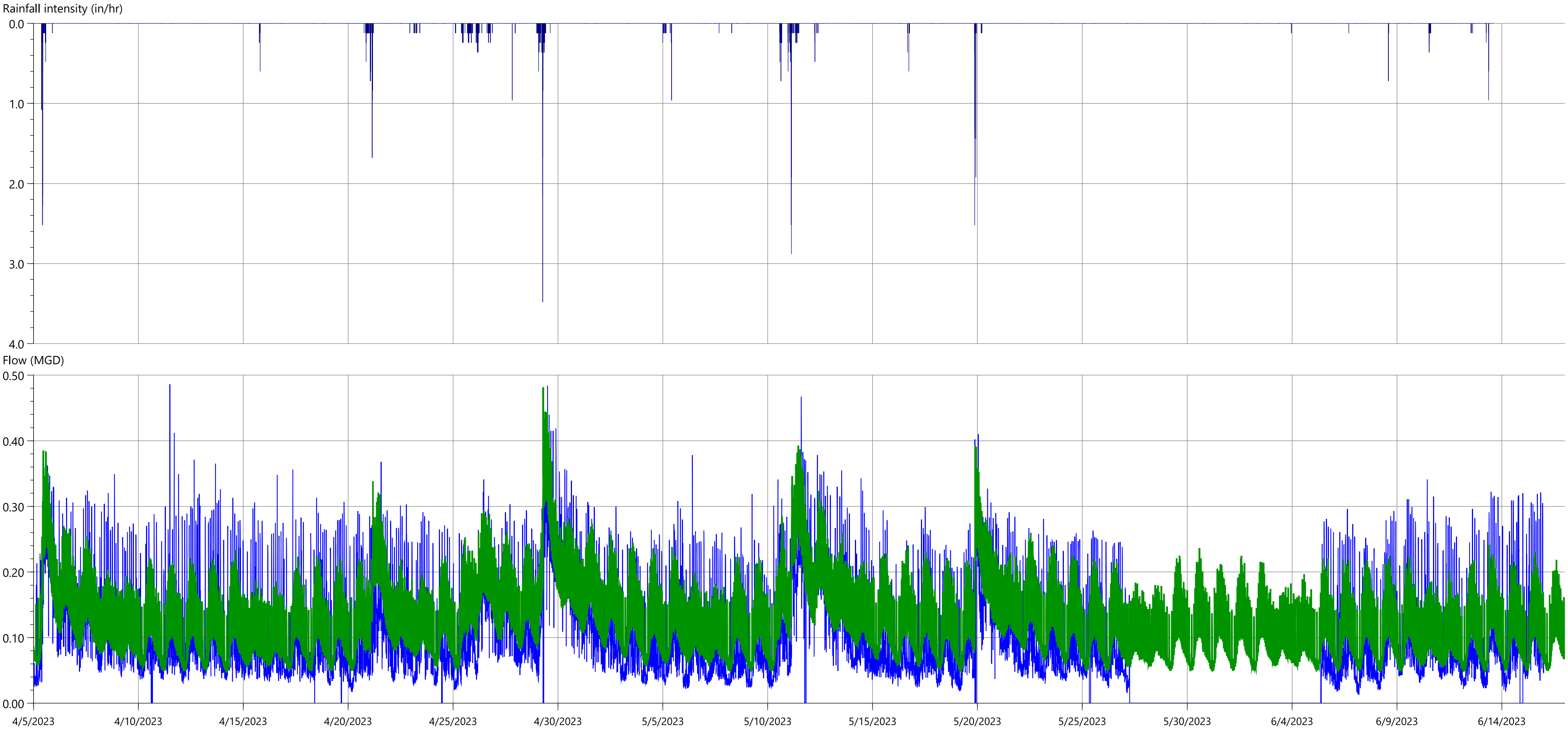
Observed / Predicted Report (Custom graph) - Hydrographs 2023 DWF Calibration

Powered by InfoWorks

APPENDIX B

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:27:25 PM) Page 1 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>WWF Calibration V2>WWF Calibration V19 FINAL!>Level Boundary Scenario 2023 Flow Monitoring Rainfall v2 (10/4/2024 7:59:36 AM)

Flow Survey Location (Obs.) ML-01, Model Location (Pred.) D/S MH1526A.1, Rainfall Profile: MLRG-1



	Rainfall			Flow		
	Depth (in)	Peak (in/hr)	Average (in/hr)	Min (MGD)	Max (MGD)	Volume (US Mgal)
Rain	10.770	3.480	0.006			
Observed				0.000	0.486	6.528
...rio 2023 Flow Monitoring Rainfall v2				0.047	0.482	8.296

Observed / Predicted Report (Custom graph) - Hydrographs 2023 WWF Calibration

Powered by InfoWorks

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:27:25 PM) Page 2 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>WWF Calibration V2>WWF Calibration V19 FINAL!>Level Boundary Scenario 2023 Flow Monitoring Rainfall v2 (10/4/2024 7:59:36 AM)
Flow Survey Location (Obs.) ML-02, Model Location (Pred.) D/S MH1371.1, Rainfall Profile: MLRG-1

	Rainfall			Flow		
	Depth (in)	Peak (in/hr)	Average (in/hr)	Min (MGD)	Max (MGD)	Volume (US Mgal)
Rain	10.770	3.480	0.006			
Observed				0.000	0.904	10.679
...rio 2023 Flow Monitoring Rainfall v2				-0.141	1.251	12.287

Observed / Predicted Report (Custom graph) - Hydrographs 2023 WWF Calibration

Powered by InfoWorks

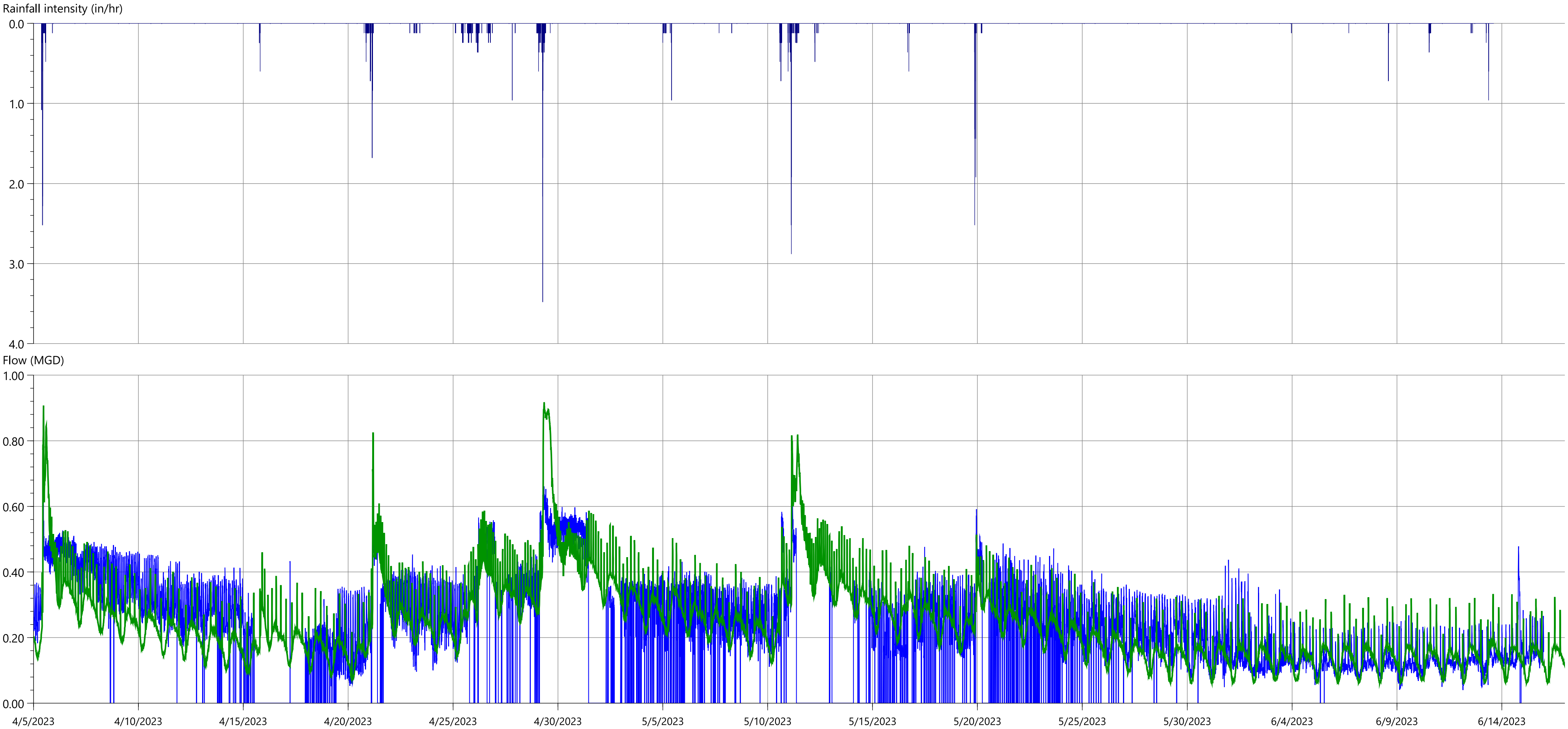
Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:27:25 PM) Page 3 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>WWF Calibration V2>WWF Calibration V19 FINAL!>Level Boundary Scenario 2023 Flow Monitoring Rainfall v2 (10/4/2024 7:59:36 AM)
Flow Survey Location (Obs.) ML-03, Model Location (Pred.) D/S MH0959A.1, Rainfall Profile: MLRG-1

	Rainfall			Flow		
	Depth (in)	Peak (in/hr)	Average (in/hr)	Min (MGD)	Max (MGD)	Volume (US Mgal)
Rain	10.770	3.480	0.006			
Observed				0.000	1.767	55.600
...rio 2023 Flow Monitoring Rainfall v2				-0.215	1.724	55.577

Observed / Predicted Report (Custom graph) - Hydrographs 2023 WWF Calibration

Powered by InfoWorks

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:27:25 PM) Page 4 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>WWF Calibration V2>WWF Calibration V19 FINAL!>Level Boundary Scenario 2023 Flow Monitoring Rainfall v2 (10/4/2024 7:59:36 AM)
Flow Survey Location (Obs.) ML-03A, Model Location (Pred.) D/S MH0005.1, Rainfall Profile: MLRG-1

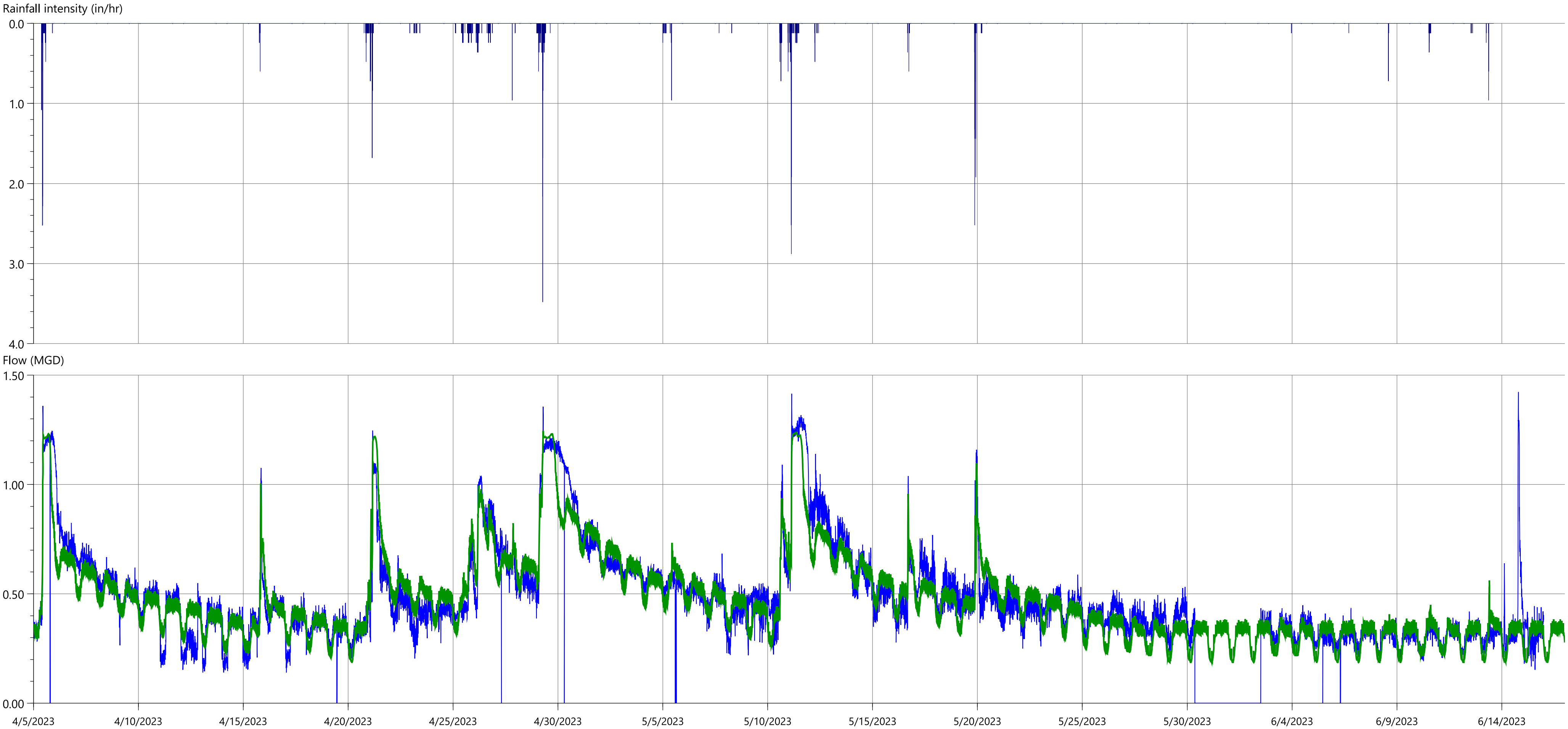


	Rainfall			Flow		
	Depth (in)	Peak (in/hr)	Average (in/hr)	Min (MGD)	Max (MGD)	Volume (US Mgal)
Rain	10.770	3.480	0.006			
Observed				0.000	0.748	15.077
...rio 2023 Flow Monitoring Rainfall v2				0.062	0.917	17.443

Observed / Predicted Report (Custom graph) - Hydrographs 2023 WWF Calibration

Powered by InfoWorks

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:27:25 PM) Page 5 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>WWF Calibration V2>WWF Calibration V19 FINAL!>Level Boundary Scenario 2023 Flow Monitoring Rainfall v2 (10/4/2024 7:59:36 AM)
Flow Survey Location (Obs.) ML-04, Model Location (Pred.) D/S MH0297.1, Rainfall Profile: MLRG-1

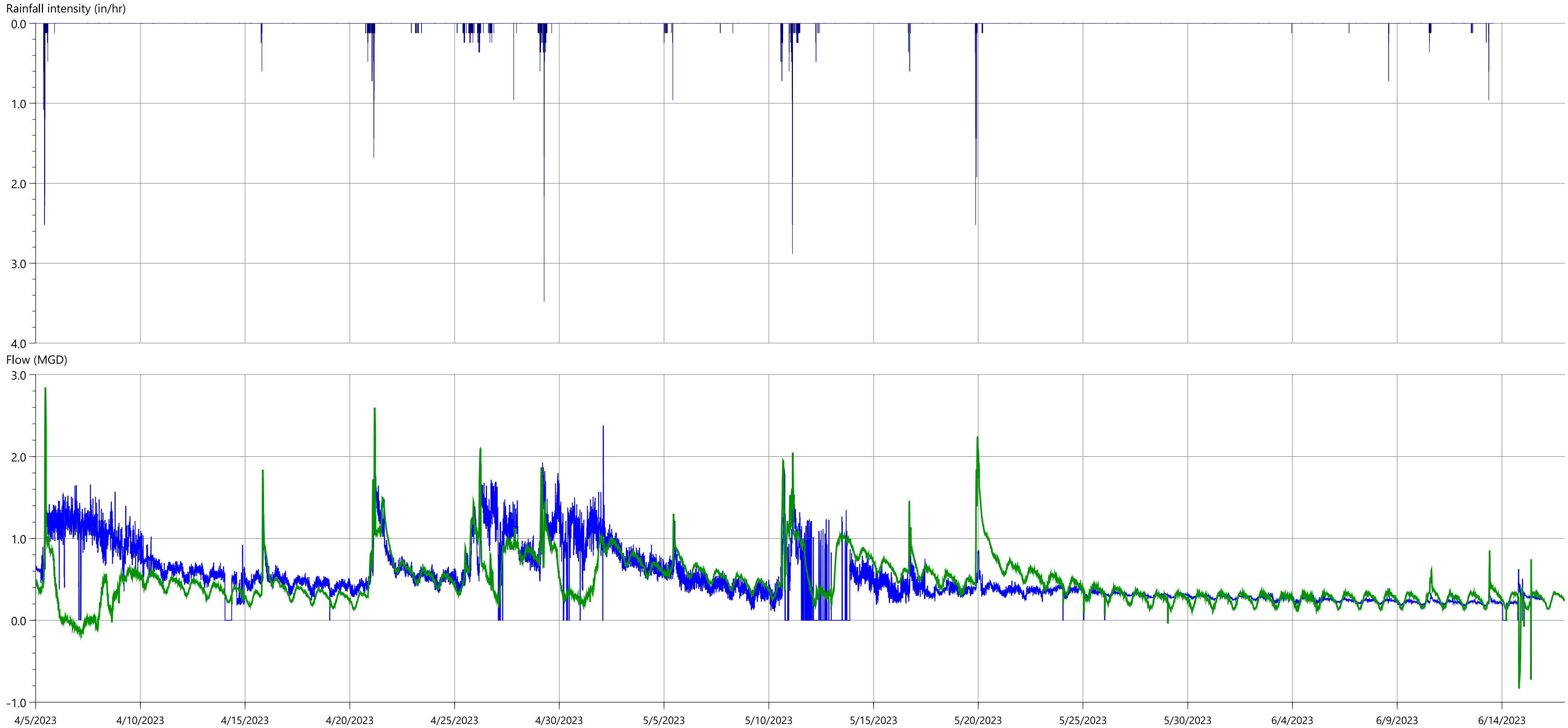


	Rainfall			Flow		
	Depth (in)	Peak (in/hr)	Average (in/hr)	Min (MGD)	Max (MGD)	Volume (US Mgal)
Rain	10.770	3.480	0.006			
Observed				0.000	1.423	33.935
...rio 2023 Flow Monitoring Rainfall v2				0.187	1.245	33.837

Observed / Predicted Report (Custom graph) - Hydrographs 2023 WWF Calibration

Powered by InfoWorks

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:27:25 PM) Page 6 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>WWF Calibration V2>WWF Calibration V19 FINAL!>Level Boundary Scenario 2023 Flow Monitoring Rainfall v2 (10/4/2024 7:59:36 AM)
Flow Survey Location (Obs.) ML-05, Model Location (Pred.) D/S MH0718.1, Rainfall Profile: MLRG-1

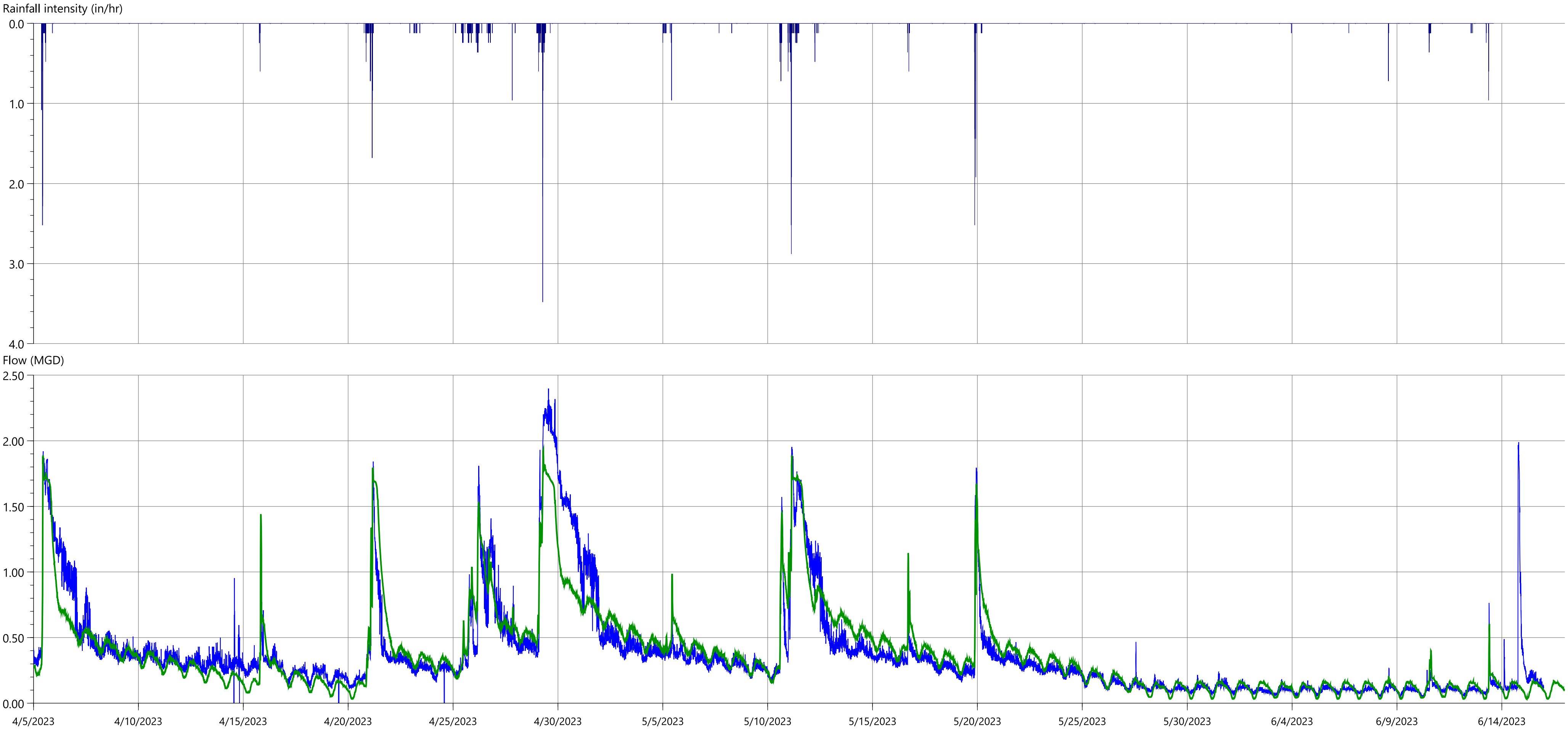


	Rainfall			Flow		
	Depth (in)	Peak (in/hr)	Average (in/hr)	Min (MGD)	Max (MGD)	Volume (US Mgal)
Rain	10.770	3.480	0.006			
Observed				0.000	2.377	36.562
...rio 2023 Flow Monitoring Rainfall v2				-0.832	2.844	34.140

Observed / Predicted Report (Custom graph) - Hydrographs 2023 WWF Calibration

Powered by InfoWorks

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:27:25 PM) Page 7 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>WWF Calibration V2>WWF Calibration V19 FINAL!>Level Boundary Scenario 2023 Flow Monitoring Rainfall v2 (10/4/2024 7:59:36 AM)
Flow Survey Location (Obs.) ML-05A, Model Location (Pred.) D/S MH0746.1, Rainfall Profile: MLRG-1



	Rainfall			Flow		
	Depth (in)	Peak (in/hr)	Average (in/hr)	Min (MGD)	Max (MGD)	Volume (US Mgal)
Rain	10.770	3.480	0.006			
Observed				0.000	2.398	27.473
...rio 2023 Flow Monitoring Rainfall v2				0.033	1.928	27.553

Observed / Predicted Report (Custom graph) - Hydrographs 2023 WWF Calibration

Powered by InfoWorks

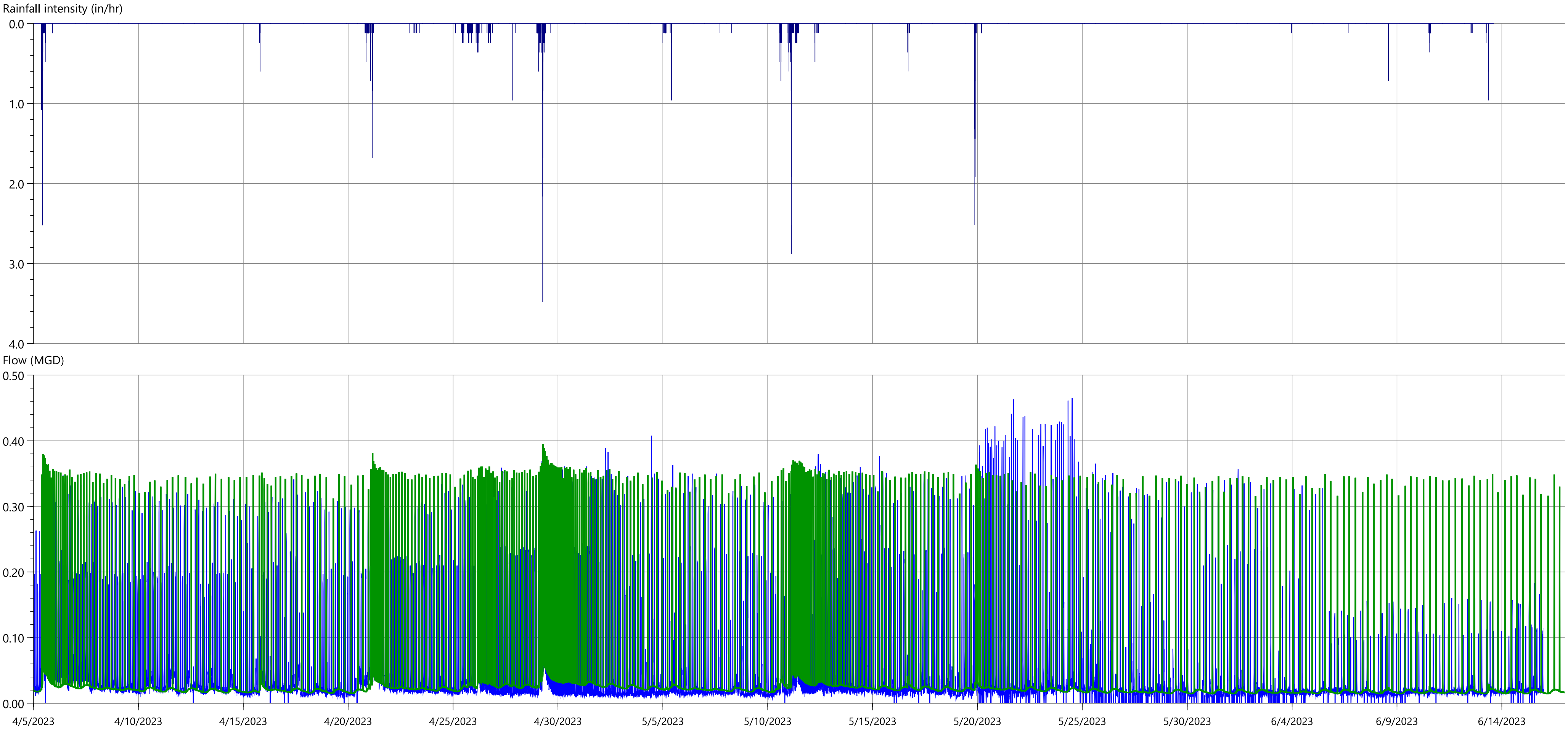
Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:27:25 PM) Page 8 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>WWF Calibration V2>WWF Calibration V19 FINAL!>Level Boundary Scenario 2023 Flow Monitoring Rainfall v2 (10/4/2024 7:59:36 AM)
Flow Survey Location (Obs.) ML-05B, Model Location (Pred.) D/S MH0912.1, Rainfall Profile: MLRG-1

	Rainfall			Flow		
	Depth (in)	Peak (in/hr)	Average (in/hr)	Min (MGD)	Max (MGD)	Volume (US Mgal)
Rain	10.770	3.480	0.006			
Observed				1.653	4.228	196.816
...rio 2023 Flow Monitoring Rainfall v2				-0.218	3.351	141.546

Observed / Predicted Report (Custom graph) - Hydrographs 2023 WWF Calibration

Powered by InfoWorks

Observed / Predicted Report Produced by ehranelkins (10/4/2024 3:27:25 PM) Page 9 of 9
Flow survey: >City of Malvern 2023>2023 Flow Monitoring - Corrected ML-05B (10/19/2023 10:26:03 AM)
Sim: >City of Malvern 2023>WWF Calibration V2>WWF Calibration V19 FINAL!>Level Boundary Scenario 2023 Flow Monitoring Rainfall v2 (10/4/2024 7:59:36 AM)
Flow Survey Location (Obs.) ML-P, Model Location (Pred.) U/S MH1150.1, Rainfall Profile: MLRG-1



	Rainfall			Flow		
	Depth (in)	Peak (in/hr)	Average (in/hr)	Min (MGD)	Max (MGD)	Volume (US Mgal)
Rain	10.770	3.480	0.006			
Observed				0.000	0.465	3.528
...rio 2023 Flow Monitoring Rainfall v2				0.015	0.395	2.191

Observed / Predicted Report (Custom graph) - Hydrographs 2023 WWF Calibration

Powered by InfoWorks

APPENDIX C

P.A.2.1 - Project A, Alternative 2, Phase 1: Proposed Lift Station near Sullenberger Avenue and Acme Street

#	Item Description	QTY	Unit	Unit Cost	Cost
1	Mobilization, Demobilization, Bonds, Insurance	1	LS	$50,000.00	$ 50,000.00
2	Property Acquisition	1	LS	$25,000.00	$ 25,000.00
3	6' Dia Manhole (0-6' depth)	1	EA	$15,000.00	$ 15,000.00
4	6' Dia Manhole (extra depth)	15	VF	$1,000.00	$ 15,000.00
5	Pump Station	1	LS	$3,500,000.00	$ 3,500,000.00
6	Electrical, Instrumentation, Controls	1	LS	$400,000.00	$ 400,000.00
7	Generator & ATS	1	LS	$200,000.00	$ 200,000.00
8	Storm Water Permit, SWPPP, & Erosion Control	1	LS	$10,000.00	$ 10,000.00
9	Trench & Excavation Safety	1	LS	$15,000.00	$ 15,000.00
10	Acceptance Testing	1	LS	$15,000.00	$ 15,000.00
11	Seeding, Sodding, & Final Clean-up	1	LS	$10,000.00	$ 10,000.00
12	Final Clean-up & Restoration	1	LS	$15,000.00	$ 15,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 4,255,000.00
				30% ENGINEERING & CONTINGENCY	$ 1,276,500.00
				TOTAL PROJECT ESTIMATE	**$ 5,531,500.00**

P.A.2.1 - Project A, Alternative 2, Phase 1: Proposed Forcemain near Sullenberger Avenue and Acme Street

#	Item Description	QTY	Unit	Unit Cost	Cost
1	Mobilization, Demobilization, Bonds, Insurance	1	LS	$100,000.00	$ 100,000.00
2	Clearing & Grubbing	1	LS	$50,000.00	$ 50,000.00
3	20" PVC, Force Main	6,500	LF	$300.00	$ 1,950,000.00
4	Connection to Ex. Junction Box	1	EA	$10,000.00	$ 10,000.00
5	2" Combination Air Valve	3	EA	$12,000.00	$ 36,000.00
6	20" Plug Valve	2	EA	$25,000.00	$ 50,000.00
7	Asphalt/Concrete Repair	25	SY	$200.00	$ 5,000.00
8	Storm Water Permit, SWPPP, & Erosion Control	1	LS	$20,000.00	$ 20,000.00
9	Trench & Excavation Safety	1	LS	$25,000.00	$ 25,000.00
10	Trench Dewatering	1	LS	$25,000.00	$ 25,000.00
11	Acceptance Testing	1	LS	$15,000.00	$ 15,000.00
12	Final Clean-up & Restoration	1	LS	$15,000.00	$ 15,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 2,301,000.00
				30% ENGINEERING & CONTINGENCY	$ 690,300.00
				TOTAL PROJECT ESTIMATE	**$ 2,991,300.00**

P.A.2.2 - Project A, Alternative 2, Phase 2: Upsizing 12” North of Chatman Creek

#	Item Description	QTY	Unit	Unit Cost	Cost
1	Mobilization, Demobilization, Bonds, Insurance	1	LS	$150,000.00	$ 150,000.00
2	5' Dia Manhole (0-6' depth)	12	EA	$10,000.00	$ 120,000.00
3	5' Dia Manhole (extra depth)	72	VF	$750.00	$ 54,000.00
4	18" PVC, Gravity Sewer	610	LF	$250.00	$ 152,500.00
5	24" PVC, Gravity Sewer	300	LF	$350.00	$ 105,000.00
6	30" PVC, Gravity Sewer	2,600	LF	$400.00	$ 1,040,000.00
7	30" Steel Encasement Pipe, Bored	80	LF	$1,000.00	$ 80,000.00
8	48" Steel Encasement Pipe, Bored	200	LF	$1,200.00	$ 240,000.00
9	Connection to Ex. Manhole	1	EA	$12,000.00	$ 12,000.00
10	Sewer Service Connection	20	EA	$1,500.00	$ 30,000.00
11	Sewer Service Line	400	LF	$150.00	$ 60,000.00
12	Asphalt/Concrete Repair	750	SY	$200.00	$ 150,000.00
13	Creek Crossing	1	LS	$25,000.00	$ 25,000.00
14	Clearing & Grubbing	1	LS	$20,000.00	$ 20,000.00
15	SWPPP & Siltation Control	1	LS	$10,000.00	$ 10,000.00
16	Trench & Excavation Safety	1	LS	$20,000.00	$ 20,000.00
17	Seeding, Sodding, & Final Clean-up	1	LS	$10,000.00	$ 10,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 2,278,500.00
				30% ENGINEERING & CONTINGENCY	$ 683,550.00
				TOTAL PROJECT ESTIMATE	**$ 2,962,050.00**

P.A.3.1 – Project A, Phase 3: Flow Equalization System

#	Item Description	QTY	Unit	Unit Cost	Cost
1	Mobilization, Demobilization, Bonds, Insurance	1	LS	$ 50,000.00	$ 25,000.00
2	Unclassified Excavation (CUT)	25,000	CY	$ 5.50	$ 137,500.00
3	FEB Dewatering	1	LS	$ 20,000.00	$ 20,000.00
4	Gravel Drive	2,800	LF	$ 40.00	$ 112,000.00
5	Rip Rap Placement	4,400	TON	$ 80.00	$ 352,000.00
6	EQ Return Pump Station	1	LS	$ 300,000.00	$ 300,000.00
7	Inlet Screen & Concrete Headwall	1	LS	$ 25,000.00	$ 25,000.00
8	8" PVC, Force Main	700	LF	$ 60.00	$ 42,000.00
9	8" Plug Valve	1	EA	$ 8,000.00	$ 8,000.00
10	2" Air/Vacuum Release Assembly	1	EA	$ 12,000.00	$ 12,000.00
11	5' Dia Manhole (0-6' depth)	1	EA	$ 10,000.00	$ 10,000.00
12	5' Dia Manhole (extra depth)	4	VF	$ 750.00	$ 3,000.00
13	24" PVC, Gravity Sewer	560	LF	$ 350.00	$ 196,000.00
14	24" Plug Valve	1	EA	$ 35,000.00	$ 35,000.00
15	Modify Existing Junction Box	1	LS	$ 75,000.00	$ 75,000.00
16	Electrical	1	LS	$ 15,000.00	$ 15,000.00
17	Acceptance Testing	1	LS	$ 5,000.00	$ 5,000.00
18	Clearing & Grubbing	1	LS	$ 15,000.00	$ 15,000.00
19	SWPPP & Erosion Control	1	LS	$ 20,000.00	$ 20,000.00
20	Trench & Excavation Safety	1	LS	$ 25,000.00	$ 25,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 1,432,500.00
				30% ENGINEERING & CONTINGENCY	$ 429,750.00
				TOTAL PROJECT ESTIMATE	**$ 1,862,250.00**

Project B – Upsizing Northern Interceptor

#	Item Description	QTY	Unit	Unit Cost	Cost
1	Mobilization, Demobilization, Bonds, Insurance	1	LS	$ 50,000.00	$ 50,000.00
2	5' Dia Manhole (0-6' depth)	15	EA	$ 10,000.00	$ 150,000.00
3	5' Dia Manhole (extra depth)	45	VF	$ 750.00	$ 33,750.00
4	18" PVC, Gravity Sewer	3,490	LF	$ 250.00	$ 872,500.00
5	24" PVC, Gravity Sewer	1,540	LF	$ 350.00	$ 539,000.00
6	30" PVC, Gravity Sewer	250	LF	$ 400.00	$ 100,000.00
7	30" Steel Encasement Pipe, Bored	380	LF	$ 1,000.00	$ 380,000.00
8	Connection to Ex. Wet Well	1	LS	$ 20,000.00	$ 20,000.00
9	Service Connection	6	EA	$ 1,500.00	$ 9,000.00
10	Sewer Service Line	250	LF	$ 150.00	$ 37,500.00
11	Asphalt/Concrete Repair	30	SY	$ 200.00	$ 6,000.00
12	Gravel Drive Repair	800	LF	$ 50.00	$ 40,000.00
13	Clearing & Grubbing	1	LS	$ 75,000.00	$ 75,000.00
14	SWPPP & Siltation Control	1	LS	$ 25,000.00	$ 25,000.00
15	Trench & Excavation Safety	1	LS	$ 25,000.00	$ 25,000.00
16	Seeding, Sodding, & Final Clean-up	1	LS	$ 15,000.00	$ 15,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 2,377,750.00
				30% ENGINEERING & CONTINGENCY	$ 713,325.00
				TOTAL PROJECT ESTIMATE	**$ 3,091,075.00**

Project C – Burris Road Sewer Upsizing Behind Train Tracks

#	Item Description	QTY	Unit	Unit Cost	Cost
1	Mobilization, Demobilization, Bonds, Insurance	1	LS	$ 50,000.00	$ 50,000.00
2	5' Dia Manhole (0-6' depth)	9	EA	$ 10,000.00	$ 90,000.00
3	5' Dia Manhole (extra depth)	27	VF	$ 750.00	$ 20,250.00
4	4' Dia Manhole (0-6' depth)	15	EA	$ 8,000.00	$ 120,000.00
5	4' Dia Manhole (extra depth)	45	VF	$ 750.00	$ 33,750.00
6	12" PVC, Gravity Sewer	1,800	LF	$ 200.00	$ 360,000.00
7	15" PVC, Gravity Sewer	1810	LF	$ 220.00	$ 398,200.00
8	18" PVC, Gravity Sewer	2,400	LF	$ 250.00	$ 600,000.00
9	24" Steel Encasement Pipe, Bored	60	LF	$ 750.00	$ 45,000.00
10	30" Steel Encasement Pipe, Bored	200	LF	$ 1,000.00	$ 200,000.00
11	Connection to Ex. Manhole	1	LS	$ 7,500.00	$ 7,500.00
12	Service Connection	60	EA	$ 1,500.00	$ 90,000.00
13	Sewer Service Line	1200	LF	$ 150.00	$ 180,000.00
14	Asphalt/Concrete Repair	1,600	SY	$ 200.00	$ 320,000.00
15	Clearing & Grubbing	1	LS	$ 10,000.00	$ 10,000.00
16	SWPPP & Siltation Control	1	LS	$ 25,000.00	$ 25,000.00
17	Trench & Excavation Safety	1	LS	$ 50,000.00	$ 50,000.00
18	Seeding, Sodding, & Final Clean-up	1	LS	$ 25,000.00	$ 25,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 2,624,700.00
				30% ENGINEERING & CONTINGENCY	$ 787,410.00
				TOTAL PROJECT ESTIMATE	**$ 3,412,110.00**

Project D – Sewer Upsizing Along Mill Street

#	Item Description	QTY	Unit	Unit Cost	Cost
1	Mobilization	1	LS	$ 50,000.00	$ 50,000.00
2	Weir Plate Diversion Manhole	1	LS	$ 20,000.00	$ 20,000.00
3	5' Dia Manhole (0-6' depth)	16	EA	$ 10,000.00	$ 160,000.00
4	5' Dia Manhole (extra depth)	48	VF	$ 750.00	$ 36,000.00
5	4' Dia Manhole (0-6' depth)	5	EA	$ 8,000.00	$ 40,000.00
6	4' Dia Manhole (extra depth)	15	VF	$ 750.00	$ 11,250.00
7	12" PVC, Gravity Sewer	1000	LF	$ 200.00	$ 200,000.00
8	15" PVC, Gravity Sewer	4,800	LF	$ 220.00	$ 1,056,000.00
9	30" Steel Encasement Pipe, Bored	80	LF	$ 1,000.00	$ 80,000.00
10	Service Connection	45	EA	$ 1,500.00	$ 67,500.00
11	Sewer Service Line	900	LF	$ 150.00	$ 135,000.00
12	Asphalt/Concrete Repair	800	SY	$ 200.00	$ 160,000.00
13	Creek Crossing	1	LS	$ 25,000.00	$ 25,000.00
14	Clearing & Grubbing	1	LS	$ 25,000.00	$ 25,000.00
15	SWPPP & Siltation Control	1	LS	$ 25,000.00	$ 25,000.00
16	Trench & Excavation Safety	1	LS	$ 50,000.00	$ 50,000.00
17	Seeding, Sodding, & Final Clean-up	1	LS	$ 25,000.00	$ 25,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 2,165,750.00
				30% ENGINEERING & CONTINGENCY	$ 649,725.00
				TOTAL PROJECT ESTIMATE	**$ 2,815,475.00**

Project E – Upsizing Sewer Upstream of Sulphur Springs Road

#	ITEM DESCRIPTION	QTY	Unit	Unit Cost	Cost
1	Mobilization, Demobilization, Bonds, Insurance	1	LS	$50,000.00	$ 50,000.00
2	10" HDPE Pipe Burst	3,270	LF	$160.00	$ 523,200.00
3	15" PVC, Gravity Sewer	840	LF	$220.00	$ 184,800.00
4	30" Steel Encasement Pipe, Bored	80	LF	$1,000.00	$ 80,000.00
5	Sewer Service Connection	13	EA	$1,500.00	$ 19,500.00
6	Sewer Service Line	260	LF	$150.00	$ 39,000.00
7	Asphalt/Concrete Repair	60	SY	$200.00	$ 12,000.00
8	Clearing & Grubbing	1	LS	$15,000.00	$ 15,000.00
9	SWPPP & Siltation Control	1	LS	$15,000.00	$ 15,000.00
10	Trench & Excavation Safety	1	LS	$20,000.00	$ 20,000.00
11	Seeding, Sodding, & Final Clean-up	1	LS	$15,000.00	$ 15,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 973,500.00
				30% ENGINEERING & CONTINGENCY	$ 292,050.00
				TOTAL PROJECT COST ESTIMATE	**$ 1,265,550.00**

Project F – Pipe Burst at Wilson Street & Park Avenue

#	Item Description	QTY	Unit	Unit Cost	Cost
1	Mobilization, Demobilization, Bonds, Insurance	1	LS	$ 25,000.00	$ 25,000.00
2	8" HDPE Pipe Burst	1,070	LF	$ 140.00	$ 149,800.00
3	Sewer Service Connection	16	EA	$ 1,500.00	$ 24,000.00
4	Sewer Service Line	320	LF	$ 150.00	$ 48,000.00
5	Asphalt/Concrete Repair	25	SY	$ 200.00	$ 5,000.00
6	Clearing & Grubbing	1	LS	$ 5,000.00	$ 5,000.00
7	SWPPP & Siltation Control	1	LS	$ 10,000.00	$ 10,000.00
8	Trench & Excavation Safety	1	LS	$ 15,000.00	$ 15,000.00
9	Seeding, Sodding, & Final Clean-up	1	LS	$ 10,000.00	$ 10,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 291,800.00
				30% ENGINEERING & CONTINGENCY	$ 87,540.00
				TOTAL PROJECT ESTIMATE	**$ 379,340.00**

Project G – Pipe Burst Along Sullenberger Avenue

#	Item Description	QTY	Unit	Unit Cost	Cost
1	Mobilization, Demobilization, Bonds, Insurance	1	LS	$ 25,000.00	$ 25,000.00
2	8" HDPE Pipe Burst	1,160	LF	$ 140.00	$ 162,400.00
3	Sewer Service Connection	12	EA	$ 1,500.00	$ 18,000.00
4	Sewer Service Line	240	LF	$ 150.00	$ 36,000.00
5	Asphalt/Concrete Repair	20	SY	$ 200.00	$ 4,000.00
6	Clearing & Grubbing	1	LS	$ 5,000.00	$ 5,000.00
7	SWPPP & Siltation Control	1	LS	$ 10,000.00	$ 10,000.00
8	Trench & Excavation Safety	1	LS	$ 15,000.00	$ 15,000.00
9	Seeding, Sodding, & Final Clean-up	1	LS	$ 10,000.00	$ 10,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 285,400.00
				30% ENGINEERING & CONTINGENCY	$ 85,620.00
				TOTAL PROJECT ESTIMATE	**$ 371,020.00**

(Crist) Sewer System Improvements - Proposed Walco Rd PS 20" Force Main

#	Item Description	QTY	Unit	Unit Cost	Cost
1	Mobilization, Demobilization, Bonds, Insurance	1	LS	$ 100,000.00	$ 100,000.00
2	Clearing & Grubbing	1	LS	$ 50,000.00	$ 50,000.00
3	20" PVC, Force Main	6750	LF	$ 300.00	$ 2,025,000.00
4	Connection to Ex. 20" D.I. Force Main	1	EA	$ 10,000.00	$ 10,000.00
5	2" Combination Air Valve	3	EA	$ 12,000.00	$ 36,000.00
6	20" Plug Valve	2	EA	$ 25,000.00	$ 50,000.00
7	Gravel Surface Repair	150	LF	$ 50.00	$ 7,500.00
8	Creek Crossing	1	LS	$ 20,000.00	$ 20,000.00
9	Storm Water Permit, SWPPP, & Erosion Control	1	LS	$ 20,000.00	$ 20,000.00
10	Trench & Excavation Safety	1	LS	$ 25,000.00	$ 25,000.00
11	Trench Dewatering	1	LS	$ 25,000.00	$ 25,000.00
12	Acceptance Testing	1	LS	$ 15,000.00	$ 15,000.00
13	Seeding, Sodding, & Final Clean-up	1	LS	$ 10,000.00	$ 10,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 2,393,500.00
				30% ENGINEERING & CONTINGENCY	$ 718,100.00
				TOTAL PROJECT ESTIMATE	**$ 3,111,600.00**

(Crist) Sewer System Improvements - Walco Rd Pump Station Rehabilitation

#	Item Description	QTY	Unit	Unit Cost	Cost
1	Mobilization, Demobilization, Bonds, Insurance	1	LS	$ 25,000.00	$ 25,000.00
2	Pump & Valve Replacements	1	LS	$ 300,000.00	$ 300,000.00
3	Flow Meter & Vault	1	LS	$ 50,000.00	$ 50,000.00
				TOTAL CONSTRUCTION ESTIMATE	$ 375,000.00
				30% ENGINEERING & CONTINGENCY	$ 112,500.00
				TOTAL PROJECT ESTIMATE	**$ 487,500.00**

rjngroup

Engineering infrastructure for tomorrow

7304 Kanis Road, Suite 5 | Little Rock, Arkansas 72204 | (501) 224-2248 | www.rjn.com