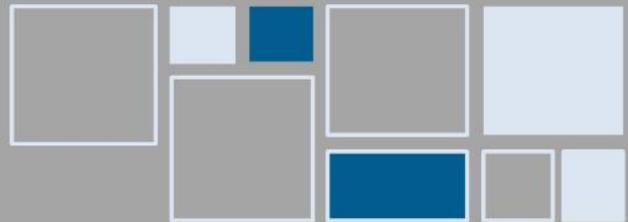




CITY OF TOMBALL

WASTEWATER MASTER PLAN

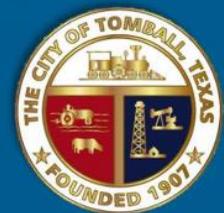


**FREES
AND
NICHOLS**

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City of Tomball

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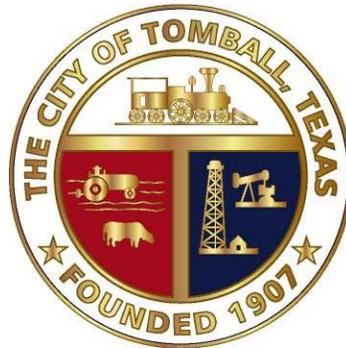


2017 WASTEWATER MASTER PLAN

Prepared for:

City of Tomball

October 2017



Prepared by:

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2017 WASTEWATER MASTER PLAN

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TMB16575

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Appendices

- Appendix A Wastewater System CIP – Planning Level Opinion of Probable Construction Cost (OPCC) Sheets
- Appendix B Lift Station Inventory
- Appendix C Sewer System Performance Report (by ADS) Incl. Flow Monitor Site Reports
- Appendix D Hydrographs and Flow Depth Plots for Wastewater Flow Monitors
- Appendix E Wastewater Diurnal Patterns
- Appendix F Collection System Field Data Forms
- Appendix G Wastewater Model Calibration Results

EXECUTIVE SUMMARY

1.0 INTRODUCTION

The City of Tomball (City) is a growing community located in Northwest Harris County, Texas. The City currently provides wastewater service to approximately 11,900 people. Like many municipalities across Texas, the wastewater collection and treatment systems are aging and in need of condition and capacity-related improvements. The population within Tomball’s wastewater service area is projected to grow to about 19,500 people by 2042. This *Wastewater Master Plan* report (study) has been prepared by Freese and Nichols, Inc. (FNI) to provide the City of Tomball with a planning tool to serve as a guide for 5-year, 10-year, and 25-year improvements to the wastewater collection and treatment system infrastructure, as well as provide guidance for ongoing inflow and infiltration (I/I) reduction efforts.

2.0 POPULATION AND DEVELOPMENT

Population and projected land use are important elements in the analysis of wastewater collection systems. Wastewater loads are dependent on the residential population and commercial development served by the collection system and affect the sizing and location of system infrastructure. A thorough analysis of historical and projected populations and developments provides the basis for future wastewater flows.

Future population projections and commercial acreage for each planning year were developed based on input from the City’s Planning, Community Development, and Engineering staff regarding proposed developments and developable acreage, as well as FNI’s analysis. **Table ES-1** presents the wastewater service area projected population for each planning period. The projected growth in commercial acreage is also included.

Table ES-1: Wastewater Service Area Projected Population

Year	Population	Annual Growth Rate	Commercial Acreage
2017	11,863	-	1,147
2022	14,438	4.0%	1,152
2027	15,726	1.7%	1,286
2042	19,463	1.4%	1,456
Average Annual Growth Rate		2.0%	-

3.0 EXISTING WASTEWATER SYSTEM

The City of Tomball’s wastewater collection system consists of two wastewater treatment plants (WWTPs), approximately 81 miles of gravity wastewater lines, 9 miles of force mains, and 10 lift stations. The wastewater collection system is divided between the North and South Service Areas that are each served by a WWTP.

4.0 WASTEWATER FLOW MONITORING

The City of Tomball contracted with ADS Environmental Services (ADS) to perform wastewater flow monitoring from November 2016 to January 2017. FNI worked with ADS to initiate the field testing and the field collected data was provided to FNI for use in this *Wastewater Master Plan*. The flow monitoring and rainfall data was used to characterize dry weather and wet weather flows at key points within the wastewater system, evaluate wet weather inflow and infiltration (I/I), and calibrate the hydraulic model of the wastewater collection system.

A wet weather analysis was performed to calculate the rate of I/I observed in each flow monitor basin. Calculating the I/I rates per flow monitor basin allowed wastewater basins to be prioritized for future sanitary sewer evaluation survey (SSES) projects. The average rate of I/I within each basin was categorized as **high**, **moderate**, or **low**. The flow meter basins, SSES priority rankings, discrete I/I rates, and categories of I/I are summarized in **Table ES-2**.

Table ES-2: Summary of I/I Rates by Flow Monitor Basin

Flow Monitor ID	WWTP Basin	Basin Priority Ranking	Discrete Basin I/I Rate (Gal/LF/in)	Category
N-05	North	1	12.6	High I/I Greater than 4.0 Gal/LF/in
S-03	South	2	4.18	
S-02	South	3	3.32	Medium I/I 2.0 – 3.9 Gal/LF/in
N-02	North	4	3.29	
N-03	North	5	3.05	
N-01	North	6	2.92	
S-04	South	7	2.59	Low I/I Less than 2.0 Gal/LF/in
N-04	North	8	1.33	
S-01	South	9	0.95	
S-05	South	10	0.66	

5.0 WASTEWATER FLOW PROJECTIONS

The performance of Tomball’s collection system is dependent on the amount of water being conveyed through the system currently and in the future. To determine locations where future capacity improvements are necessary, existing flows and future wastewater flow projections must be developed. FNI developed projected average day and peak wastewater flows for the 5-year, 10-year, and 25-year planning periods for this study. These flows were utilized in the wastewater hydraulic model to plan future wastewater system improvements. Wastewater treatment plants are typically sized for average day flows, while the collection system infrastructure, including lift stations, is sized to convey peak wastewater flows.

The total projected average day wastewater flows for each WWTP Service Area in each planning period are shown in **Table ES-3**.

Table ES-3: Summary of Projected Average Day Wastewater Flows

Wastewater Treatment Plant Service Area	Average Day Flow (MGD)			
	2017	2022	2027	2042
North WWTP	0.71	0.94	0.99	1.06
South WWTP	0.90	0.91	1.12	1.56
Total City	1.61	1.85	2.11	2.62

6.0 WASTEWATER MODEL DEVELOPMENT AND CALIBRATION

Model Development

The InfoSewer® modeling software by Innowyze® was selected as the hydraulic modeling software for this project. FNI built and calibrated the hydraulic wastewater model to serve as a basis for all existing and future system analyses modeling scenarios and CIP development. The model consists of approximately 721 links and 727 nodes, including 3 outfalls, 7 lift stations, and 14 pumps. Approximately 178,700 feet (34 miles) of gravity wastewater line within the City’s collection system is included in the wastewater model.

Model Calibration

FNI performed dry and wet weather calibrations so that the flows in the hydraulic model closely matched observed dry weather average day flows and wet weather peak flows. The dry and wet weather calibration results provide confidence that the model closely matches real world conditions and is suitable to use for hydraulic analyses and CIP development. The model is calibrated well within industry standards.

7.0 HYDRAULIC MODELING AND WASTEWATER SYSTEM ANALYSES

Hydraulic analyses were conducted to identify deficiencies in the City's existing wastewater collection system and establish a capital improvements plan to address deficiencies in the existing system and accommodate the projected wastewater flows through 2042.

Collection System Capacity Analyses

A 2-year 24-hour design storm was utilized for the existing and future system analyses. This design storm is commonly used in Texas and provides a reasonable balance between level of service and wastewater infrastructure cost. FNI created future hydraulic model scenarios to analyze needed capital improvements. These scenarios added the projected peak wastewater loads for each planning period to the existing system. This approach shows what improvements are needed in each of the three CIP planning periods (2022, 2027, and 2042).

8.0 WASTEWATER TREATMENT PLANT ANALYSES

The wastewater flow projections developed in **Section 5.0** show that additional WWTP capacity is needed within the next 25 years to treat the identified wastewater flows within the study area.

WWTP Consolidation Analysis

FNI conducted a 25-year life cycle cost analysis to compare the financial impacts of operating two WWTPs vs. consolidating to a single WWTP. The 25-year WWTP life cycle costs were computed for each alternative in 2017 dollars. The results of the consolidation analysis are summarized in **Table ES-4** and include construction, contingency, and engineering. The 25-year cost of operating the City's two existing WWTPs and expanding the South WWTP by 0.5 MGD is less than either of the consolidation alternatives. **Based on this analysis, FNI does not recommend consolidation of the City's WWTPs at this time.** FNI

recommends that WWTP consolidation be re-evaluated during the City’s next wastewater master planning effort.

Table ES-4: WWTP Consolidation 25-Year Life Cycle Cost Summary ⁽¹⁾⁽²⁾

WWTP Alternative ⁽³⁾	Phase	Category	Project	Capital Cost	Total 25-Year Life Cycle Cost (2017 \$)	No. of WWTPS
Alternative 1 Both WWTPs remain in service and 0.5 MGD Expansion to South WWTP (Includes 10-Year rehabilitation projects at North WWTP)	Beyond 10 Years	Treatment	0.5 MGD Expansion to South WWTP	\$6,240,000	\$47,349,000	2
		Conveyance	N/A	\$0		
		Rehabilitation	North WWTP Critical Needs Improvements – Priority 3	\$6,921,800		
	Alternative 1 Total Capital Cost			\$13,161,800		
Alternative 2a Decommission North WWTP and 1.5 MGD Expansion to South WWTP	Beyond 10 Years	Treatment	1.5 MGD Expansion to South WWTP	\$18,720,000	\$56,481,000	1
		Treatment	Decommission North WWTP	\$468,000		
		Conveyance	Diversion Infrastructure	\$10,554,400		
	Alternative 2a Total Capital Cost			\$29,742,400		
Alternative 2b Decommission North WWTP and 1.5 MGD Expansion to South WWTP	Within 5 Years	Treatment	1.5 MGD Expansion to South WWTP	\$18,720,000	\$50,421,000	1
		Treatment	Decommission North WWTP	\$468,000		
		Conveyance	Diversion Infrastructure	\$10,554,400		
	Alternative 2b Total Capital Cost			\$29,742,400		

- (1) All costs include construction, contingency, and engineering
- (2) Assumptions for O&M Costs: \$0.80/1,000 Gallons for 1 WWTP; \$1.40/1,000 Gallons for 2 WWTPs
- (3) North and South WWTP Phase 1 Critical Needs Improvements currently planned for FY 2018 were not included in the 25-Year Life Cycle Cost Analyses

WWTP Capacity Analyses

FNI conducted capacity analyses at the North and South WWTPs to develop WWTP expansion recommendations. The 25-year flow projections in this study indicate that no capacity expansion is needed at the North WWTP. The 25-year flow projections in this study indicate a lack of capacity at the

South WWTP. FNI recommends that the City plan for a 0.5 MGD expansion at the South WWTP to occur beyond 2027.

9.0 INTEGRATED WASTEWATER CAPITAL IMPROVEMENTS PLAN

An integrated capital improvements plan was developed for the City's wastewater system. These projects address deficiencies in the existing collection system's ability to convey and treat wastewater flows and provide the required conveyance and treatment capacity to serve the projected residential and commercial growth through the 25-year planning period. The integrated wastewater CIP also includes sanitary sewer evaluation survey (SSES) projects to address the undesirable levels of I/I in the collection system, as well as WWTP improvements identified in the City's recent *2016 Critical Needs Assessment of North and South WWTPs* by FNI.

Capital costs were calculated for all recommended improvements and do not include individual service connections or subdivision lines. The costs are provided as estimates based on previous similar engineering experience in 2017 dollars and include an allowance for engineering, surveying, and contingencies. Costs do not include easements or land acquisition.

Additional Development

The infrastructure recommendations in this report incorporate the projected flows from the population and developments discussed in **Section 3.0**, within the wastewater study area (**Figure 3-1**).

It is recommended that existing and future wastewater system capacity be evaluated for any additional development beyond what is identified in this study.

Table ES-5 summarizes the costs for each project by phase of the integrated wastewater CIP in 2017 dollars.

Table ES-5: Wastewater Capital Improvements Plan Summary

Phase	Project Number	Project Name	Cost (2017 \$)
by 2022	1	Treatment Plant Critical Needs Projects – Priority 1 (Phase II)	\$ 816,700 ⁽¹⁾
	2	SSES for Basin N-05 (Field Work and Rehabilitation)	\$ 278,100
	3	Replacement 10/12-inch Gravity Lines along Alma/James Streets	\$ 1,718,000
	4	SSES for Basin S-03 (Field Work and Rehabilitation)	\$ 3,573,900
	5	Replacement 21/24-inch North Willow Street Gravity Line	\$ 872,100
	6	SSES for Basin S-02 (Field Work and Rehabilitation)	\$ 521,200
	7	Replacement 15/18-inch Gravity Main along Tomball Pkwy (Hwy 249 B)	\$ 2,741,900
	Total 2017 - 2022		
by 2027	8	FM 2920 Lift Station Expansion, Replacement Force Main and Gravity Line Expansion	\$ 4,265,300
	9	SSES for Basin N-02 (Field Work and Rehabilitation)	\$ 1,464,600
	10	North WWTP Improvements - Priority 2	\$ 6,921,800
	11	SSES for Basin N-03 (Field Work and Rehabilitation)	\$ 2,389,400
	12	South WWTP Improvements - Priority 2	\$ 3,184,000
	13	SSES for Basin N-01 (Field Work and Rehabilitation)	\$ 556,900
	14	Hicks Lift Station Expansion and Replacement Force Main	\$ 1,558,200
	Total 2023 - 2027		
by 2027	15	SSES for Basin S-04 (Field Work and Rehabilitation)	\$ 1,463,700
	16	0.5 MGD Expansion of South WWTP	\$ 6,240,000
	Total 2028 - 2042		
Total 25-Year Wastewater CIP Cost			\$ 38,565,800

(1) Contractor markup for change order planned to be executed in 2018

1.0 INTRODUCTION

The City of Tomball (City) is a growing community located in Northwest Harris County, Texas. The City currently provides wastewater service to approximately 11,900 people. Like many municipalities across Texas, the wastewater collection and treatment systems are aging and in need of condition and capacity-related improvements. The population within Tomball’s wastewater service area is projected to grow to about 19,500 people by 2042. This *Wastewater Master Plan* report (study) has been prepared to provide the City of Tomball with a planning tool to serve as a guide for 5-year, 10-year, and 25-year improvements to the wastewater collection and treatment system infrastructure, as well as provide guidance for ongoing inflow and infiltration (I/I) reduction efforts.

1.1 SCOPE OF WORK

Freese and Nichols, Inc. (FNI) was retained in 2016 by the City of Tomball to prepare a Wastewater Master Plan. The goals of this *Wastewater Master Plan* were to evaluate the integrity of the existing wastewater systems and to recommend a phased capital improvement plan (CIP) through the year 2042. The recommended improvements will serve as a basis for the design, construction, and financing of facilities required to meet Tomball’s wastewater capacity and system renewal needs. The major elements of the scope of this project included:

- Incorporation of Wastewater Flow Monitoring Data
- Wastewater System Inventory and Model Development
- Wastewater System Model Calibration
- Population and Wastewater Flow Projections
- Wastewater Collection System Capacity and Operations Analyses
- Wastewater System CIP and Report

1.2 LIST OF ABBREVIATIONS

The list of abbreviations used in this report are included in **Table 1-1**.

Table 1-1: List of Abbreviations

Abbreviation	Actual
AD	Average Day
ADS	ADS Environmental Services
AADF	Annual Average Daily Flow
ASCE	American Society of Civil Engineers
CCTV	Closed-Circuit Television
CIP	Capital Improvement Plan
d/D	Depth to Diameter Ratio
EPS	Extended Period Simulation
EST	Elevated Storage Tank
ETJ	Extraterritorial Jurisdiction
FNI	Freese and Nichols, Inc.
gal/LF	Gallons per Linear Foot
GIS	Geographic Information System
gpad	Gallons per Acre per Day
gpcd	Gallons per Capita per Day
gpm	Gallons per Minute
HGAC	Harris-Galveston Area Council
HGL	Hydraulic Grade Line
ID	Identification Number
I/I	Inflow and Infiltration
LF	Linear Feet
LS	Lift Station
MCC	Motor Control Center
MD	Maximum Day
MG	Million Gallons
MGD	Million Gallons per Day
OPCC	Opinion of Probable Construction Cost
O&M	Operations and Maintenance
PF _D	Dry Weather Peaking Factor
PF _w	Wet Weather Peaking Factor
PH	Peak Hour
psi	Pounds per Square Inch
RBA	Risk Based Assessment
SCADA	Supervisory Control and Data Acquisition
SF	Square Feet
SH	State Highway
SSES	Sanitary Sewer Evaluation Survey



Abbreviation	Actual
SSO	Sanitary Sewer Overflow
TBRG	Tipping Bucket Rain Gauge
TCEQ	Texas Commission on Environmental Quality
TIN	Triangulated Irregular Network
TPDES	Texas Pollutant Discharge Elimination System
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
USGS	United States Geological Survey
WEF	Water Environment Federation
WWTP	Wastewater Treatment Plant

2.0 EXISTING WASTEWATER SYSTEM

The City of Tomball’s wastewater collection system consists of two wastewater treatment plants (WWTPs), approximately 81 miles of gravity wastewater lines, 9 miles of force mains, and 10 lift stations. The existing wastewater system is shown on **Figure 2-1**. The flow monitor basins utilized throughout this study are also shown on **Figure 2-1**. The wastewater flow monitoring is discussed further in **Section 4.0**.

2.1 WASTEWATER SERVICE AREAS AND TREATMENT PLANTS

The wastewater collection system is divided between the North and South Service Areas that are each served by a WWTP. In addition to the 10 lift stations in the collections system, the North WWTP has one influent lift station and the South WWTP has two influent lift stations that all pump incoming gravity flows to the plants’ headworks. Table 2-1 summarizes the permitted capacities and outfall information for the City’s North and South WWTPs.

Table 2-1: Wastewater Treatment Plant Facilities

WWTP Name -- TPDES Permit No.	Permitted Capacities		Permitted Outfall
	Average Daily Flow (MGD)	Peak Flow (MGD)	
North WWTP -- WQ0010616001	1.5	4.5	HCFCO ditch J231-00-00, thence to Bogs Gully, thence to Spring Creek
South WWTP -- WQ0010616002	1.5	6.0	HCFCO ditch M121-00-00, thence to Willow Creek, thence to Spring Creek

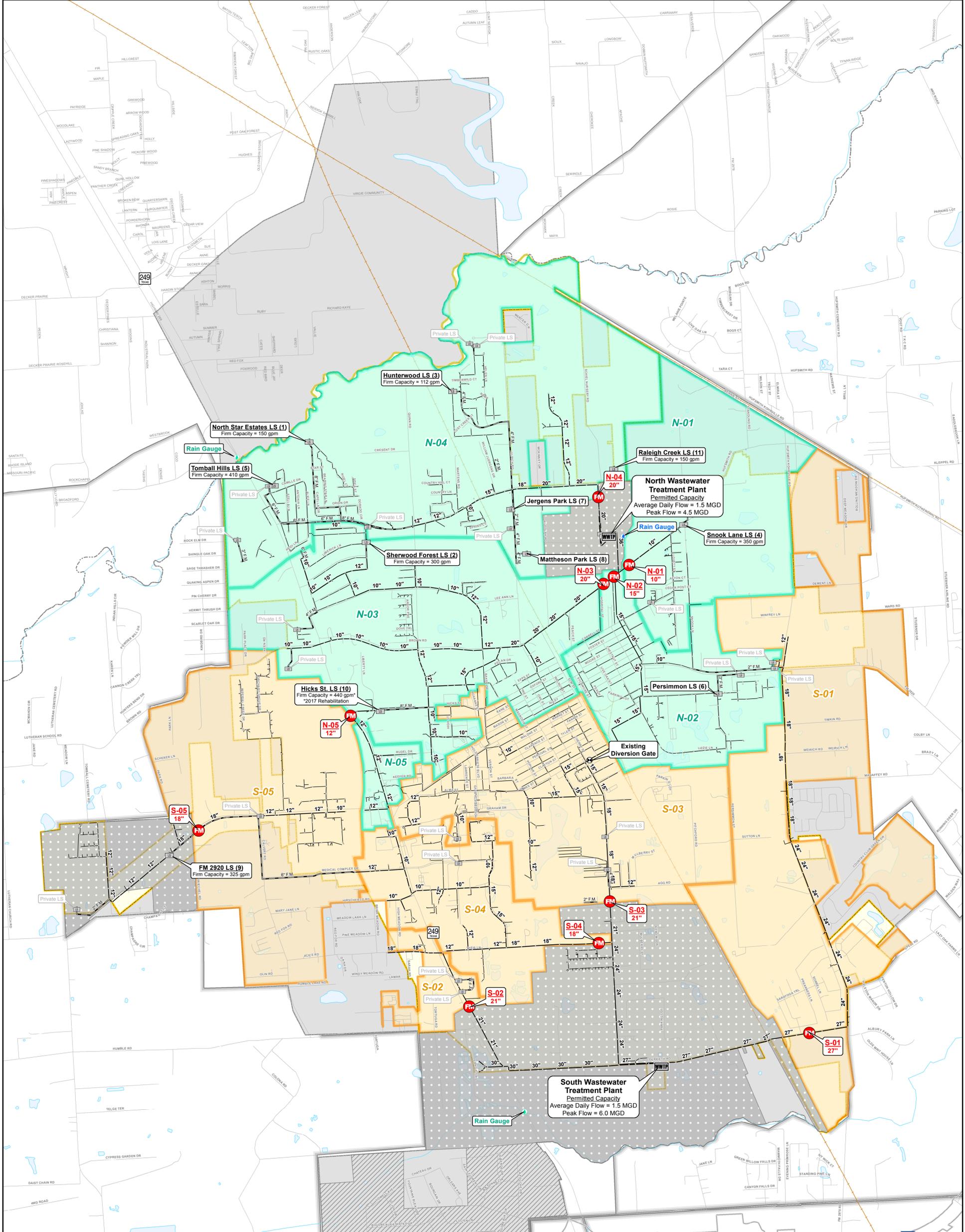


FIGURE 2-1
CITY OF TOMBALL
EXISTING WASTEWATER SYSTEM
AND FLOW MONITOR BASINS
LEGEND

- Flow Monitor
- Harris County Rain Gauge
- ADS Rain Gauge
- Existing Diversion Gate
- Lift Station
- Private Lift Station
- Wastewater Treatment Plant
-
-
-
-
- Pond/Lake
- Tomball City Limit
- Tomball ETJ
- Houston ETJ
- County Line
- Road
- Railroad
- Stream

FLOW MONITORS

Flow Monitor ID
 Sewer Line Diameter

FLOW MONITOR BASINS

- North Basin
- South Basin
- Not Served WW
- Downstream of Flow Monitor



0 1,400 2,800

SCALE IN FEET

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2.2 LIFT STATIONS AND FORCE MAINS

The City owns and maintains 10 lift stations located throughout the North and South Service Areas. These lift stations have approximately 8 miles of associated force mains, with diameters ranging from 2-inches to 8-inches. City staff provided available drawings and additional information, including field measure down data, to FNI. FNI obtained additional information from pump vendors and ground elevations and compiled all available information into a lift station inventory. A summary of the lift stations is presented in **Table 2-2**. The full lift station inventory is included in **Appendix B**.

Table 2-2: Lift Station Summary

Lift Station Name (No.)	No. of Pumps	Firm Capacity ⁽³⁾ (gpm)	Horse Power	TDH (ft)	Wet Well Diameter (ft)	Wet Well Depth (ft)
Northstar (No. 1)	2	150 ⁽²⁾	15	-	8 x 8	20
Sherwood (No. 2)	2	300	5	-	4	18.7
Hunterwood ⁽¹⁾ (No. 3)	2	112	7.5	63	6	17.9
Snook Lane (No. 4) <i>(Snook Lane & Hufsmith Road)</i>	2	115 ⁽²⁾	2	-	5	19.8
Tomball Hills (No. 5)	2	410	35	140	8	27
Persimmon (No. 6)	2	<i>Unknown</i>	3	-	4	20
Jergens Park (No. 7)	2	<i>Unknown</i>	2	-	3	-
Matheson Park (No. 8)	2	<i>Unknown</i>	5	-	4	-
FM2920 & Park Road (No. 9)	2	325	15	77	6	20
Hicks ⁽¹⁾ (No. 10)	2	440	7.5	36	8	23.9
Raleigh Creek (No. 11)	2	350	5	30	8	32

(1) Rehabilitated in 2017

(2) Modeling assumption; manufacturer data unavailable

(3) Firm capacity is defined as the maximum flow rate achievable, under design conditions, with the largest pump out of service.

2.3 GRAVITY MAINS

Tomball’s existing wastewater system consists of approximately 81 miles of gravity collector mains and interceptors. Pipeline diameters range in size from 2-inches to 36-inches. **Figure 2-2** illustrates the percentage of pipe length by diameter. Information on materials is missing for 71% of the pipes in the collection system. The known materials (based on the City’s GIS) are presented as percentages of the total system length on **Figure 2-3**. The majority of the known wastewater lines material is PVC or PVCS.

Figure 2-2: Gravity Pipe Length by Diameter

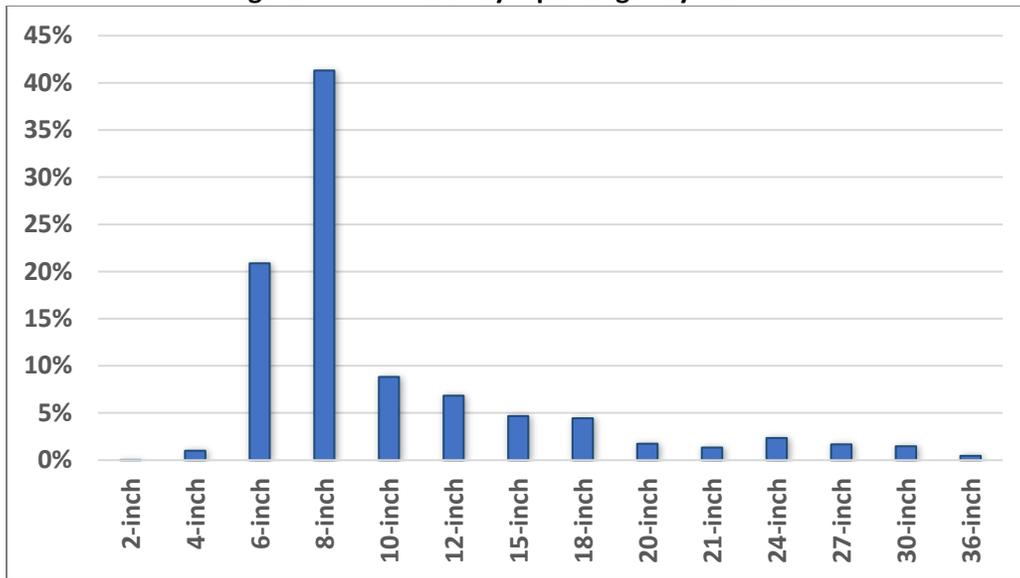
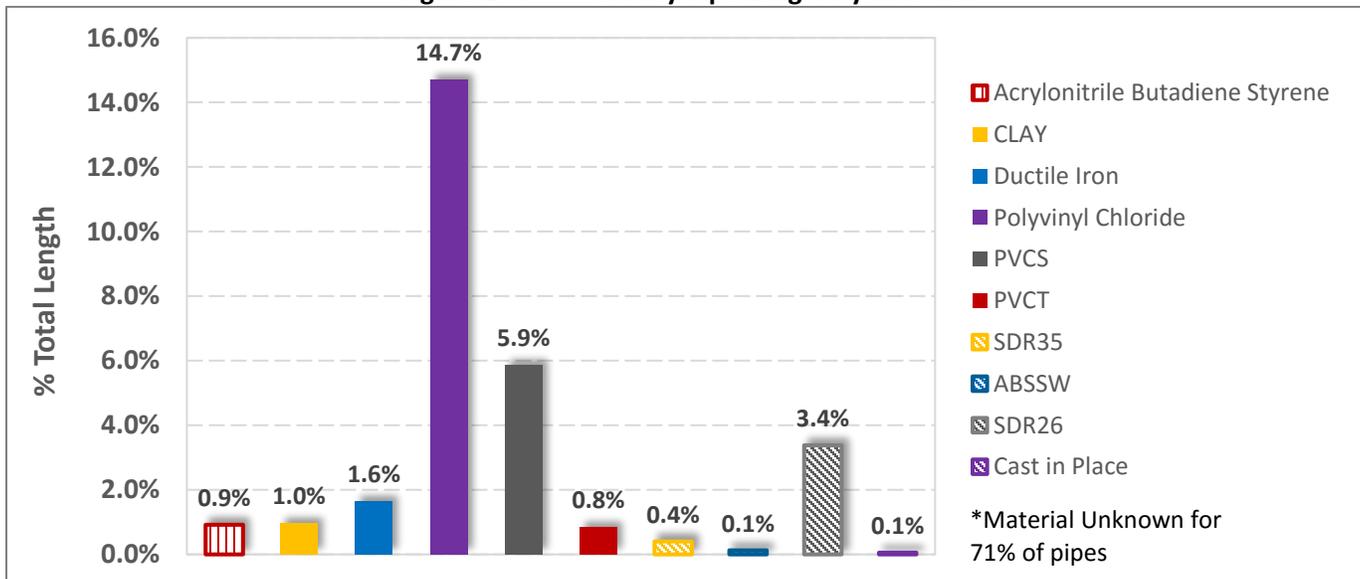


Figure 2-3: Gravity Pipe Length by Material



3.0 POPULATION AND DEVELOPMENT

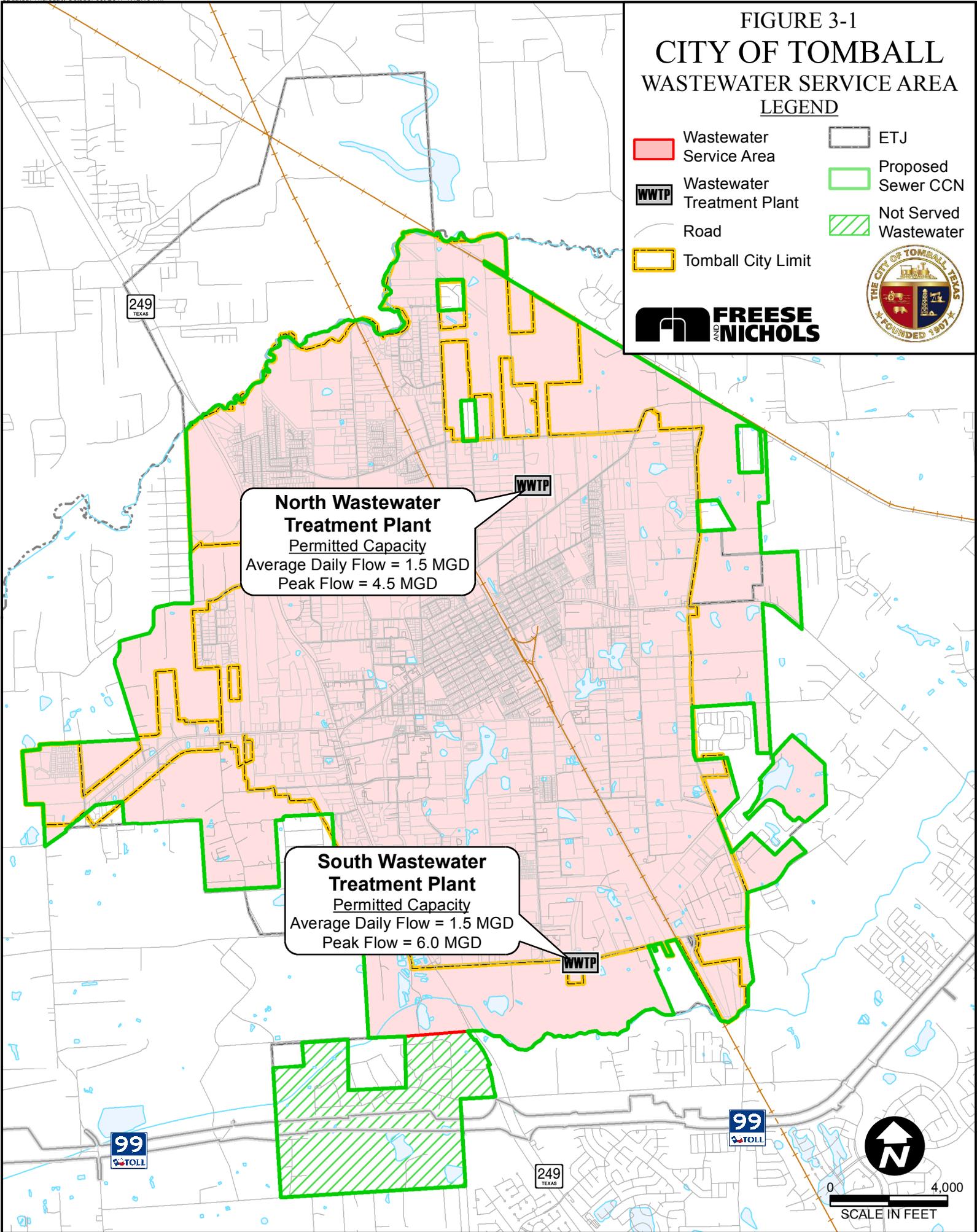
Population and projected land use are important elements in the analysis of wastewater collection systems. Wastewater loads are dependent on the residential population and commercial development served by the collection system and affect the sizing and location of system infrastructure. A thorough analysis of historical and projected populations and developments provides the basis for future wastewater flows.

3.1 WASTEWATER SERVICE AREA

The service area for this study is the City's proposed sewer Certificate of Convenience and Necessity (CCN), with the exception of the Boudreaux Estates subdivision. The wastewater service area is shown in **red** on **Figure 3-1**.

FIGURE 3-1
CITY OF TOMBALL
WASTEWATER SERVICE AREA
LEGEND

- Wastewater Service Area
- Wastewater Treatment Plant
- Road
- Tomball City Limit
- ETJ
- Proposed Sewer CCN
- Not Served Wastewater



North Wastewater Treatment Plant
Permitted Capacity
Average Daily Flow = 1.5 MGD
Peak Flow = 4.5 MGD

South Wastewater Treatment Plant
Permitted Capacity
Average Daily Flow = 1.5 MGD
Peak Flow = 6.0 MGD





3.2 HISTORICAL POPULATION

According to the US Census, the City’s population increased from 9,089 in 2000 to 10,753 in 2010. The annual historical Tomball populations from 2000 through 2017 are shown in **Table 3-1**. Population estimates for 2001-2009, and 2011-2014 are from the Houston Galveston Area Council (HGAC). The average annual growth rate from 2000 through 2014 ranges from 0.6% to 3.3%, with an average of 1.6%. The populations for 2015, 2016, and 2017 are estimated using the 1.64% growth rate observed in 2014.

Table 3-1: Historical Population

Year	Wastewater Service Area Population ⁽¹⁾	Annual Growth Rate (%)
2000 ⁽¹⁾	9,089	-
2001	9,389	3.3%
2002	9,537	1.6%
2003	9,641	1.1%
2004	9,726	0.9%
2005	9,839	1.2%
2006	10,133	3.0%
2007	10,243	1.1%
2008	10,403	1.6%
2009	10,628	2.2%
2010 ⁽²⁾	10,753	1.2%
2011	10,935	1.7%
2012	11,047	1.0%
2013	11,117	0.6%
2014	11,299	1.64%
2015 ⁽³⁾	11,484	1.64%
2016 ⁽³⁾	11,672	1.64%
2017 ⁽³⁾	11,863	1.64%

(1) 2001 – 2009, and 2011 – 2014 population estimates from HGAC

(2) U.S. Census data for Tomball City

(3) 2015, 2016, 2017 population estimates based on 1.64% growth rate from 2014

3.3 PROJECTED POPULATION AND DEVELOPMENTS

The magnitude and distribution of the growth in population and commercial acreage will dictate where future wastewater infrastructure is required. It is important to note that projecting future population is challenging, especially for relatively small geographic areas such as individual cities, because it can be

difficult to predict how fast or slow development will occur when there are a variety of circumstances that can impact it.

Future population projections and commercial acreage for each planning year were developed based on input from the City’s Planning, Community Development, and Engineering staff regarding proposed developments and developable acreage, as well as FNI’s analysis. Based on the projected developments and historical trends, an average annual growth rate of 4.0% was used to project the 2017 – 2022 wastewater service area population, 1.7% to project the 2023 – 2027 population and 1.4% to project the 2028 – 2042 population. This is equivalent to an average annual growth rate of 2.0% over the next 25 years. **Table 3-2** presents the wastewater service area projected population for each planning period. The projected growth in commercial acreage is also included.

Table 3-2: Wastewater Service Area Projected Population

Year	Population	Annual Growth Rate	Commercial Acreage
2017	11,863	-	1,147
2022	14,438	4.0%	1,152
2027	15,726	1.7%	1,286
2042	19,463	1.4%	1,456
Average Annual Growth Rate		2.0%	-

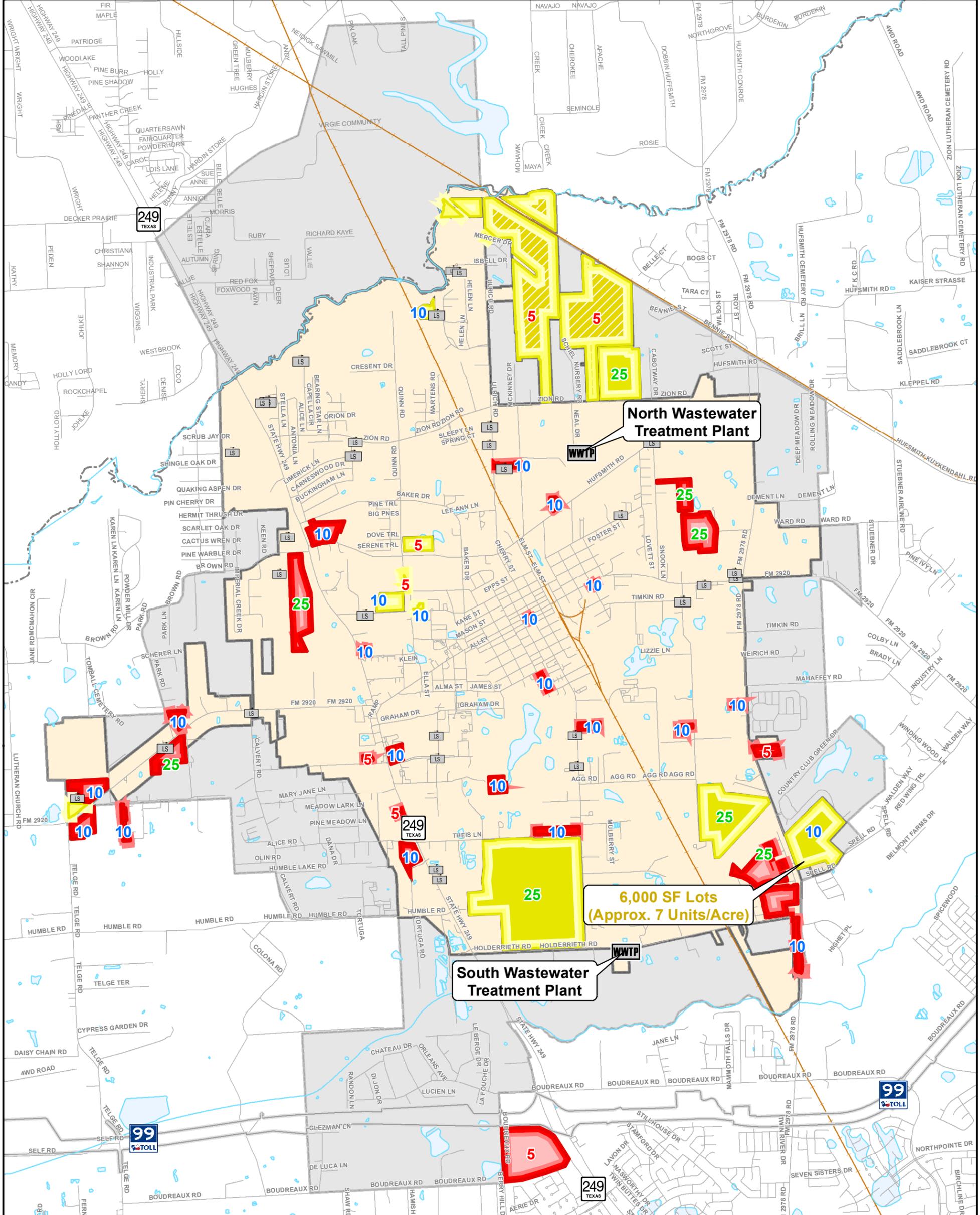
The total population and commercial acreage for each planning year was distributed throughout the City using the future developments as identified by the City’s Planning, Community Development, and Engineering staff. **Figure 3-2** shows the location of anticipated developments.

The *2009 Tomball Comprehensive Plan* provided assumptions for anticipated residential and commercial land use, and the City directed that the ‘Low’ and ‘Medium’ Density classifications be utilized for the majority of the residential developments. These classifications are defined as 2.0 units per acre and 4.5 units per acre, respectively. The comprehensive plan specified a density of 2.6 people per unit. This density was used to determine the population resulting from anticipated developments. Detailed information on projected population growth by wastewater system basin is included in **Table 3-3**. Existing populations within each wastewater basin were based on the historical water meter billing addresses.



Table 3-3: Population Projections by Wastewater Basin

Wastewater Basin		2017	2022	2027	2042
North WWTP Basin	N-01	864	871	871	1391
	N-02	806	806	806	806
	N-03	3,071	3,193	3,322	3,322
	N-04	2460	4906	4968	4968
	N-05	262	262	262	262
	Unmetered	13	13	13	13
	Subtotal	7,476	10,051	10,242	10,762
South WWTP Basin	S-01	0	0	956	1,681
	S-02	1,854	1,854	1,854	1,854
	S-03	1,248	1,248	1,248	1,248
	S-04	596	596	596	945
	S-05	231	231	231	231
	Unmetered	458	458	599	2,742
	Subtotal	4,387	4,387	5,484	8,701
Total	11,863	14,438	15,726	19,463	



North Wastewater Treatment Plant

**6,000 SF Lots
(Approx. 7 Units/Acre)**

South Wastewater Treatment Plant

FUTURE DEVELOPMENTS

- Commercial
- Residential**
- Medium Density* (4.5 Units/Acre)
- Combined Low and Medium Density* (2.0 - 4.5 Units/Acre)

***Dwelling Units/Acre defined in City's 2009 Comprehensive Plan**

**FIGURE 3-2
CITY OF TOMBALL
ANTICIPATED FUTURE DEVELOPMENTS
LEGEND**

LS Lift Station	Stream	ETJ
LS Private Lift Station	Pond/Lake	Planning Year
Wastewater Treatment Plant	County Line	5-Year
Road	City Limit	10-Year
Railroad		25-Year

FREES & NICHOLS



4.0 WASTEWATER FLOW MONITORING

The City of Tomball contracted with ADS Environmental Services (ADS) to perform wastewater flow monitoring from November 2016 to January 2017. FNI worked with ADS to initiate the field testing and the field collected data was provided to FNI for use in this *Wastewater Master Plan*. The flow monitoring and rainfall data was used to characterize dry weather and wet weather flows at key points within the wastewater system, evaluate wet weather inflow and infiltration (I/I), and calibrate the hydraulic model of the wastewater collection system.

4.1 FIELD TESTING

Dry weather and wet weather system responses within the two WWTP service areas were evaluated by installing wastewater flow monitors to observe and document existing flow conditions. Rainfall data was simultaneously collected with rain gauges. A total of 10 flow monitors and one rain gauge were used for this study. All flow monitors and the rain gauge were installed and maintained by ADS Environmental Services (ADS).

4.1.1 Flow Monitor and Rain Gauge Placement

Flow monitoring locations were chosen to support the goals of the wastewater system evaluation and overall *Wastewater Master Plan*. FNI worked with the City to choose flow monitoring sites. A total of 10 flow monitors were placed throughout the collection system. Five flow monitors were located in each of the North and South Service Areas. Locations were chosen at major outfalls within the service areas such that the linear footage of lines between each flow monitor was relatively consistent. Consideration was also given to areas of the wastewater system with known or suspected I/I issues. In the North Service Area, four flow monitors were used to isolate the wastewater flows entering the WWTP from the north and the south gravity lines. In the South Service Area, three flow monitors were used to isolate the wastewater flows entering the WWTP from the 30-inch, 24-inch, and 27-inch gravity lines to the east, north, and west, respectively. The flow monitor locations were used to delineate 10 flow monitor basins. The rain gauge was installed at the North WWTP to capture rainfall in Tomball during the field testing period. The locations of the flow monitors and rain gauge are provided in **Table 4-1**. The WWTP service areas, flow monitor basins, and flow monitor and rain gauge locations are shown on **Figure 3-1**.

Figure 4-1 displays a schematic showing the relationships between the service areas, flow monitors, and flow monitor basins. Installation reports with more detailed location information for the flow monitors and rain gauge are included in the Sewer System Performance Report (by ADS) in **Appendix C**.

Table 4-1: Flow Monitor and Rain Gauge Locations

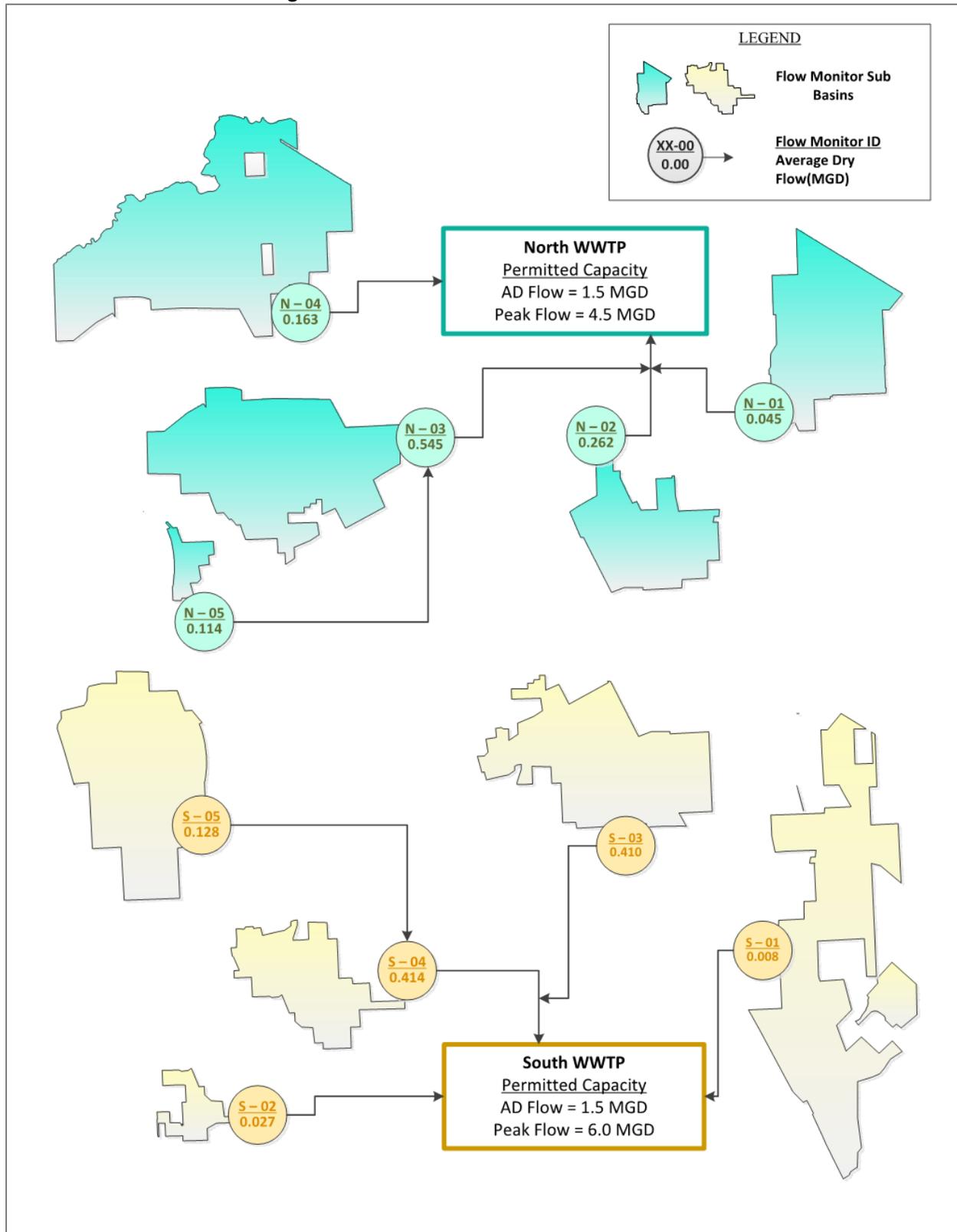
WWTP Basin	Flow Monitor ID	Line Diameter ⁽¹⁾ (in)	Location / Address	GIS Manhole ID
North WWTP	N-01	9.75	3 Manholes East of 511 Hufsmith Road	1260
	N-02	18	Across from 511 Hufsmith Road	1377
	N-03	27.25	Near Hospital Street & Hufsmith Road	1264
	N-04	20.25	1523 Neal Drive	372
	N-05	12.0	29230 Hwy 249	316
South WWTP	S-01	27.25	11519 Holderrieth Road	49
	S-02	20.5	27350 Highway 249	244
	S-03	20.5	1626 South Cherry Street	1016
	S-04	17.5	Theis Lane, West of Cherry Street	439
	S-05	17.0	FM 2920, West of Park Road	268
Rain Gauge ID		Location / Address		
RG-01		North WWTP, 615 East Hufsmith Road		

(1) Field verified pipe diameters (by ADS)

4.1.2 Field Testing Period

ADS installed the wastewater flow monitors and rain gauge over a period of several days in November 2016. The wastewater flow monitoring and rainfall data collection began on November 29, 2016, and continued through February 5, 2017, for a duration of 69 days.

Figure 4-1: Flow Monitor Basin Schematic



4.1.3 Flow Monitor and Rain Gauge Equipment

Wastewater flow monitoring was performed using area-velocity flow monitors manufactured, installed, and maintained by ADS. Flow monitors were mounted near the top of each manhole and were connected to flow, depth, and velocity sensors positioned in the incoming wastewater pipe. Each flow monitor was equipped with an ultrasonic depth sensor mounted at the crown of the wastewater line and a velocity sensor mounted at or near the invert of the wastewater line. A pressure depth sensor was also mounted at or near the invert to measure surcharge depths. For each flow monitor location, the following procedures were followed:

- Site Investigation – ADS reviewed available wastewater maps and verified preliminary flow monitor locations. A trained field crew then investigated each identified location to confirm whether suitable hydraulic conditions exist. In some cases, the actual site was relocated upstream or downstream from the suggested location in order to obtain better hydraulic conditions, provide better access, or mitigate safety concerns.
- Equipment Installation – Following final site selection, flow monitors were installed using a stainless-steel band with attached sensors (ultrasonic depth, velocity, and pressure depth).
- Sensor Calibration – Prior to exiting the manhole, independent measurements of flow, depth, and velocity were obtained and compared to the recorded measurements by the flow monitor. These measurements were used to compute any depth and velocity adjustments needed to fine-tune the recorded measurements by the flow monitor.
- Routine Maintenance – Each temporary flow monitor location was visited weekly to collect data. During each visit, the flow data were reviewed on-site to verify data quality, the flow monitor battery was checked, and the sensors were cleaned, where necessary. Independent flow depth and velocity measurements were obtained to confirm the accuracy of the flow monitor. If problems were identified, they were corrected or the flow monitor was replaced.

Rainfall during the study period was captured at the North WWTP using a standard tipping bucket rain gauge supplied by ADS. This type of rain gauge is the most common technology available and operates by funneling rainfall to a bucket assembly that is divided into two equal compartments. When one compartment has collected a known amount of rainfall, the bucket tips and drains its contents. Each tip of the bucket generates an electronic pulse that is recorded by an ADS RainAlert II data logger.

Additionally, rainfall data was collected from two Harris County rain gauges located around Tomball.

4.1.4 Flow Monitor and Rain Gauge Data

Flow monitoring and rain gauge data were collected in five-minute time step intervals. Hydrographs and flow depth plots for each flow monitor site are provided in **Appendix D**. The hydrographs display flow rate data vs. time for the duration of the field testing period, along with the observed rainfall intensities. Similarly, the depth plots show the depth of flow vs. time. Diurnal patterns showing the dry weather flow weekday and weekend flow patterns for each flow monitor site are provided in **Appendix E**.

4.2 FLOW MONITOR AND RAIN GAUGE DATA EVALUATION

FNI reviewed and evaluated the flow monitor and rain gauge data collected during the field testing period. The following sections discuss the measured rain gauge rainfall data, and the observed dry and wet weather flow rates and depths.

4.2.1 Rainfall Data Evaluation

Three rainfall events of interest were observed during the flow monitoring period (December, 2016 – February, 2017). These storm event dates, and the corresponding storm durations and total rainfall amounts, are shown in **Table 4-2**. The measured five-minute rainfall intensities are plotted with the flow monitor data on the hydrographs and flow depth plots in **Appendix D**. The observed rainfall and the associated measured flow responses were used to calibrate the hydraulic model to observed wet weather conditions.

Table 4-2: Rainfall Event Data during Flow Monitoring

Storm Date	Duration (min)	Duration (hours)	Total Rainfall Depth (in)
12/3/2016	3,480	58	4.36
1/2/2017	240	4	1.95
1/17/2017	2,100	35	2.64

Studies that utilize calibrated, dynamic hydraulic models (as in this *Master Plan*) typically utilize a storm event called a design storm to generate peak wet weather flows for the analyses of collection systems. Design storms are characterized by a recurrence interval and duration, and have an associated total rainfall amount. Typical design storm events used in Southeast Texas are 2-year, 6-hour storms; 5-year, 6-hour storms; and 2-year, 24-hour storms. The total rainfall amount for each design storm is location-

specific. **Table 4-3** presents the total rainfall amounts for Tomball for the three commonly used design storms, according to the *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima* for Texas. The observed storm events during this study (**Table 4-3**) produced significant flow response at the majority of the flow monitor sites; however, they were smaller rainfall events than these design storms.

Table 4-3: Flow Monitor and Rain Gauge Locations

Design Storm (Recurrence interval, Duration)	Duration (hours)	Rainfall (inches)
2-year, 6-hour	6	2.9
5-year, 6-hour	6	4.0
2-year, 24-hour	24	4.5

4.2.2 Wastewater Flow Rates and Peaking Factors

Dry weather flow conditions are characterized by evaluating flow monitor data observed during normal conditions, excluding wet weather events and the periods associated with the recovery from these events. The average dry weather and maximum dry weather flow rates are determined from the dry weather diurnal pattern for each flow monitor location and summarized in **Table 4-4**. The resulting dry weather peaking factor (PF_D) is also provided. The 1-hour peak wet weather flow rate for each flow monitor location is also provided, along with the corresponding wet weather peaking factor (PF_W). Wet weather peaking factors above 4 are typically considered high and are highlighted **red** in **Table 4-4**.

Table 4-4: Dry Weather and Wet Weather Flow Rates

Flow Monitor ID	Average Dry Weather Flow (MGD)	Max Dry Weather Flow (MGD)	Dry Weather Peaking Factor (PF _D)	1-Hr Peak Wet Weather Flow (MGD)	Wet Weather Peaking Factor (PF _W)
			<u>Max Dry Flow</u> Average Dry Flow		<u>Peak 1-Hr Wet Flow</u> Average Dry Flow
N-01	0.05	0.07	1.47	0.30	6.6
N-02	0.26	0.29	1.10	3.04	11.6
N-03	0.55	0.66	1.22	2.03	3.7
N-04	0.16	0.22	1.35	1.59	9.8
N-05	0.11	0.16	1.42	0.55	4.8
S-01	0.01	0.01	1.38	0.45	56.4
S-02	0.03	0.04	1.33	0.19	7.0
S-03	0.41	0.48	1.16	1.88	4.6
S-04	0.41	0.55	1.32	1.05	2.5
S-05	0.13	0.18	1.39	0.24	1.9

4.2.3 Wastewater Depth to Diameter Ratios

The maximum flow depths during dry weather and wet weather flows, their corresponding depth-to-diameter (d/D) ratios, and the manhole depths at each flow monitoring site are provided in **Table 4-5**. Depth-to-diameter ratios can be used to identify capacity issues in wastewater systems. The American Society of Civil Engineers (ASCE) and the Water Environment Federation (WEF) recommend that sewers with diameters up to 15 inches be designed to flow with dry weather d/D ratios of 0.5, and sewers with diameters 18 inches and larger be designed to flow with dry weather d/D ratios of 0.75. Wet weather d/D ratios should not exceed 1.0, as this indicates surcharging in the system.

The dry weather d/D ratios at all flow monitor locations meet the recommended criteria. This indicates adequate capacity in the system to convey dry weather flows. The wet weather d/D ratios show that four of the flow monitor locations surcharged, indicating a hydraulic grade line above the top of the pipe and insufficient capacity to convey observed maximum wet weather flows. None of the observed surcharges resulted in overflows at the flow monitor locations. The four wet weather d/D ratios greater than 1.0 are highlighted **red** in **Table 4-5**. One of the sites in the North WWTP basin indicated surcharging to within 3 feet of the manhole rim. This was at site N-05, located directly upstream of the Hicks Lift Station, and this surcharge depth is highlighted **red** in **Table 4-5**.

Table 4-5: Dry Weather and Wet Weather Depth to Diameter Ratios

Flow Monitor ID	Field Verified Pipe Inner Diameter (in)	Max Dry Depth (in)	Dry Weather d/D	Max Wet Depth (in)	Wet Weather d/D	Surcharge Depth Above Pipe (ft)	Surcharge Depth Below Rim (ft)	Manhole Depth ⁽¹⁾ (ft)
N-01	9.75	2.13	0.22	9.75	1.00	-	-	9.7
N-02	18.0	2.81	0.16	18.0	1.00	-	-	15.8
N-03	27.25	3.92	0.14	33.14	1.22	0.5	7.7	10.5
N-04	20.25	3.40	0.17	96.82	4.78	6.4	6.1	14.2
N-05	12.0	1.74	0.15	100.22	8.35	7.4	2.1	10.5
S-01	27.25	1.05	0.04	24.32	0.89	-	-	10.5
S-02	20.5	1.03	0.05	3.58	0.17	-	-	15.3
S-03	20.5	4.86	0.24	10.39	0.51	-	-	16
S-04	17.5	6.02	0.34	8.57	0.49	-	-	9.5
S-05	17.0	3.85	0.23	48.40	2.85	2.6	5.5	9.5

(1) Field verified manhole depths (by ADS)

4.2.4 Inflow and Infiltration (I/I) Analysis

During rainfall events, significant amounts of extraneous water can enter a sewer system. A comparison of flow monitor data from dry weather and wet weather periods can provide a quantification of inflow and infiltration (I/I). This can be thought of as the “leakiness” of a flow monitor basin. An evaluation of I/I rates (gallons of rainwater per linear foot of pipe per inch of rain) was conducted for the ten flow monitor basins delineated in this study.

A wet weather analysis was performed to measure each flow monitor basin’s flow response to the three rainfall events and to calculate normalized I/I values per basin. This was accomplished by subtracting the wastewater flows during average dry days within the field testing period from the flows observed during the rainfall events. The resulting volumes of I/I were then normalized by dividing by the linear footage of lines in each respective flow monitor basin and the amount of rainfall. The resulting I/I rates from the three rainfall events were then averaged to determine each basin’s mean I/I value reflective of all observed rainfall events.

The three rainfall events captured during the field testing period and utilized in the I/I analysis are illustrated in the rainfall hyetographs on **Figure 4-2**. The results of the I/I analysis are presented in **Table 4-6**. I/I rates greater than 4.0 Gal/in/LF are considered to be high and are highlighted **red**. The I/I rates are displayed graphically on **Figure 4-3**.



Figure 4-2: Rainfall Hyetographs

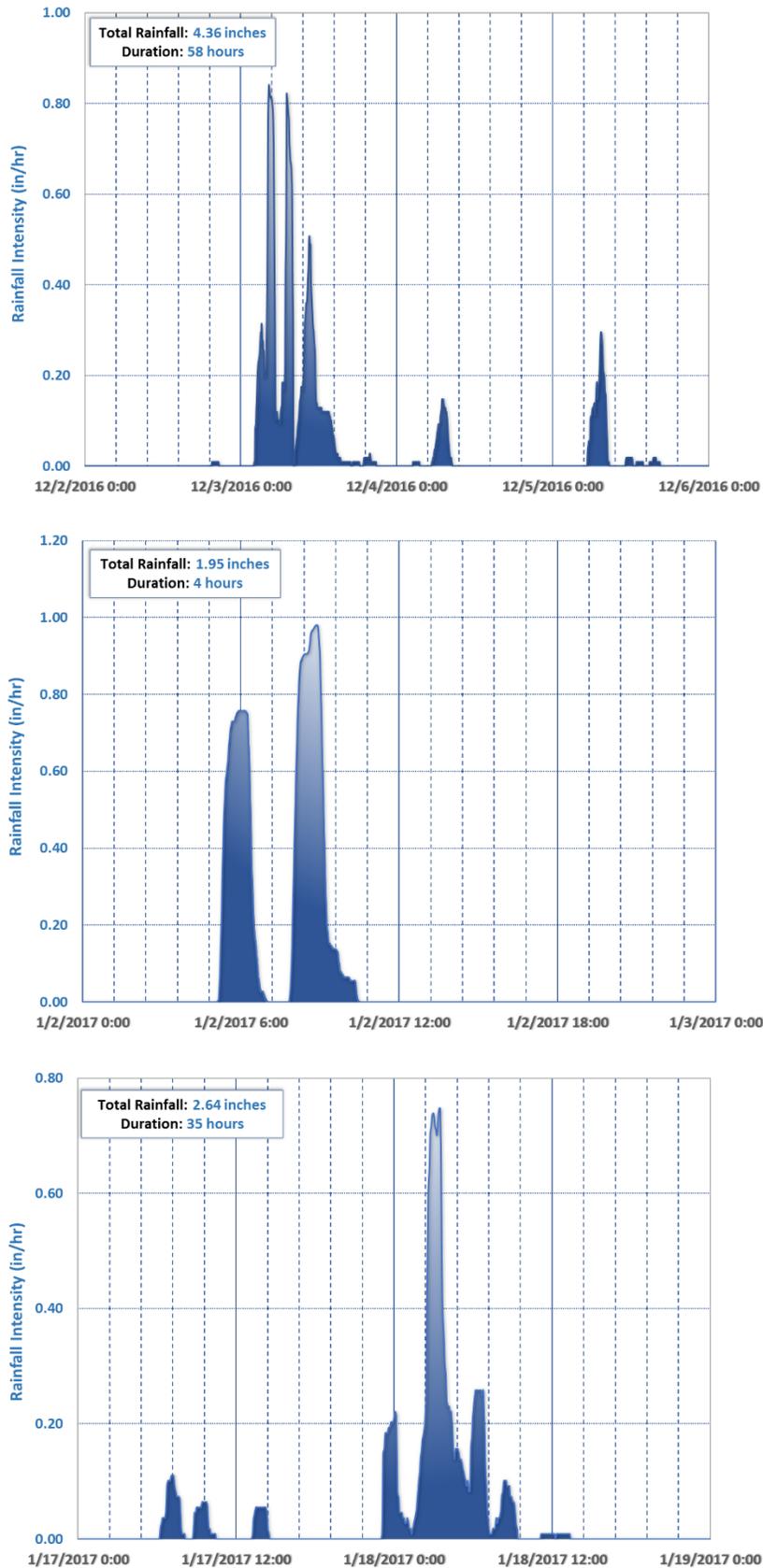
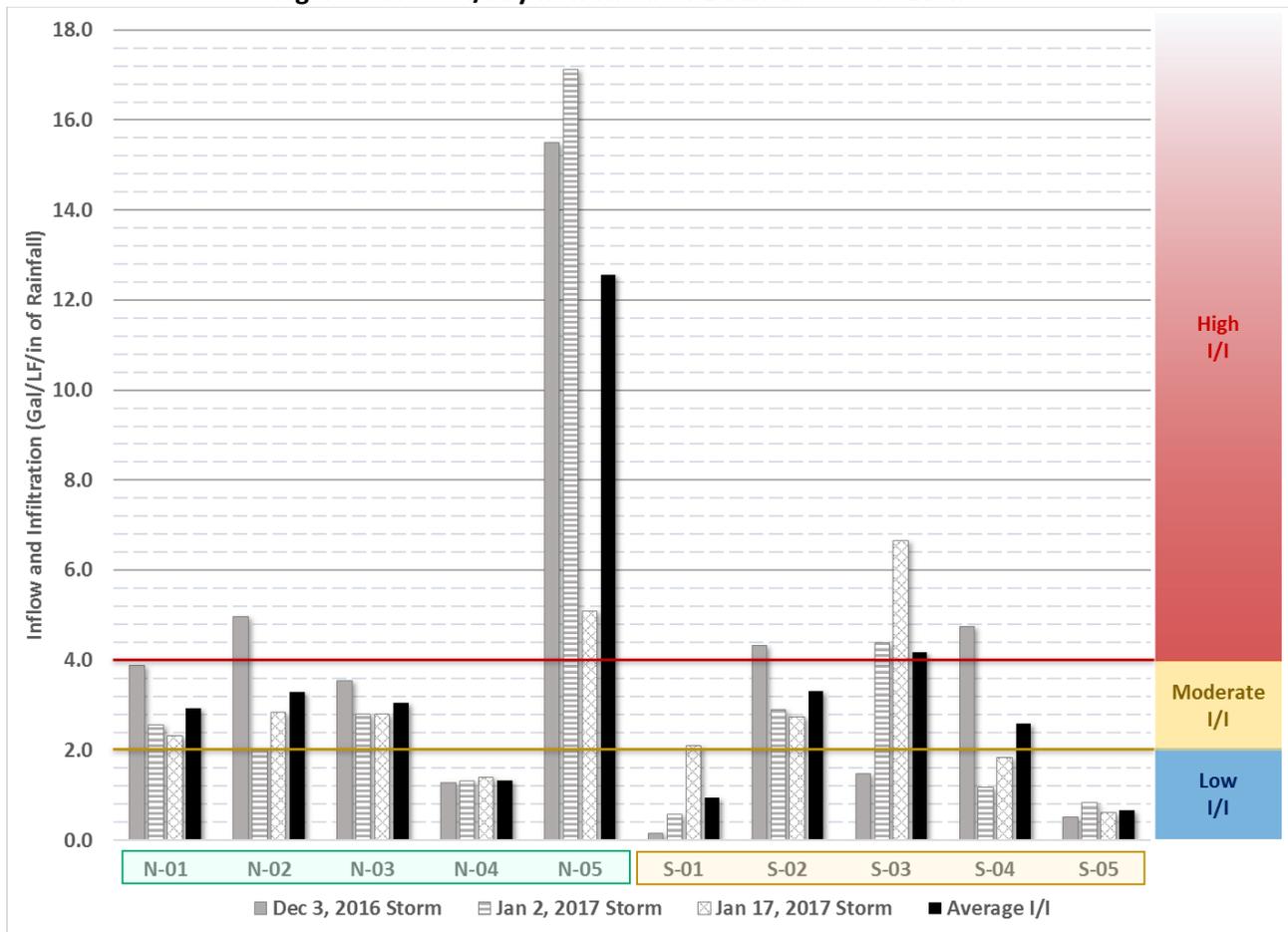


Table 4-6: I/I by Flow Monitor Basin and Storm Event

WWTP Basin	Flow Monitor ID	Normalized Basin I/I (Gal/LF/in)			
		12/3/2016 Storm Event	1/2/2017 Storm Event	1/17/2017 Storm Event	Average
North WWTP	N-01	3.89	2.56	2.33	2.92
	N-02	4.97	2.05	2.85	3.29
	N-03	3.55	2.80	2.80	3.05
	N-04	1.28	1.32	1.39	1.33
	N-05	15.51	17.11	5.08	12.6
South WWTP	S-01	0.16	0.58	2.10	0.95
	S-02	4.33	2.90	2.74	3.32
	S-03	1.48	4.38	6.66	4.18
	S-04	4.75	1.17	1.85	2.59
	S-05	0.52	0.84	0.62	0.66

Figure 4-3: I/I by flow Monitor Basin and Storm Event



4.3 FIELD DATA COLLECTION SUMMARY

The flow monitor and rain gauge data provided information that was utilized in the wastewater hydraulic modeling and CIP development for the wastewater system study. The results of the data analysis are presented below.

4.3.1 Hydraulic Modeling Data Quality

The five-minute data collected from the temporary flow monitors and rain gauge is suitable to calibrate the hydraulic model. The seven-day period from December 12 through December 18, 2016, provided consistent, dry weather flow data from all 10 flow monitor sites. Storm events from December 3, 2016 and January 2, 2017 provided good flow data for wet weather calibration. The hydraulic model was calibrated to dry weather flows from the one-week period beginning December 12th, 2016 and wet weather flows from the December 3, 2016 and January 2, 2017 storm events.

There are occasional gaps in the data collected by flow monitors N-01, N-02, and S-04, and flow monitors S-01 and S-03 did not collect data for the first six days of the field testing period. These periods were not used to compute dry weather flows and did not affect the hydraulic model calibration. There is a loss in flow data during some rainfall events when the sewer lines surcharge and water flows backwards over the velocity sensor. This is typical, and wet weather calibration was still able to be conducted utilizing the depth of flow data measured during these storm events.

4.3.2 Flow Monitor Site Hydraulics and System Performance Summary

An analysis of flow monitoring site hydraulics and dry and wet weather flows was performed. Observations and recommendations are summarized below:

- Dry weather peaking factors and depth-to-diameter (d/D) ratios indicate that the major wastewater lines have adequate capacity to convey current dry weather flows.
- Five of the flow monitor locations indicated surcharged water levels during wet weather events; however, none of these water levels reached the manhole rims. The closest a surcharged level came to a manhole rim at a monitored site was 2.1 feet (upstream of the Hicks Lift Station).
- The 27-inch pipe monitored by S-01 had an average dry weather flow of 0.008 MGD, indicating available conveyance capacity for additional flows.

- There was an uncharacteristic spike in the depth and flow rates at the S-05 flow monitor site upstream of the FM 2920 & Park Road Lift Station. The City confirmed that this was due to a loss of power to the lift station from an auto accident on January 7th, 2017.
- The flow depth data from flow monitor site N-04 indicates numerous surcharges at all three rain events during the flow monitoring period. This site is on the 21-inch line on Neal Road upstream of the North WWTP. The significant surcharging observed coupled with the minimal spikes in flow rates indicate the influent lift station at the North WWTP is most likely surcharging during rain events.
- Silt was observed at two of the flow monitoring sites: N-03 and S-01. The measured silt depths were 1-inch at both locations. Silt accumulation can cause loss of capacity in the system. Therefore, these areas should be inspected periodically as part of a preventative sewer cleaning program to determine the frequency of cleaning needed at these locations.

4.3.3 Inflow and Infiltration (I/I) Summary

A wet weather analysis was performed to calculate the rate of I/I observed in each flow monitor basin. Calculating the I/I rates per flow monitor basin allowed wastewater basins to be prioritized for future sanitary sewer evaluation survey (SSES) projects. These are discussed further in **Section 9.0**. The I/I information was combined with hydraulic capacity modeling of the projected future wastewater system loads to prioritize system improvements in the integrated CIP. The 10 flow meter basins were ranked according to the average rates of discrete I/I measured during the three storm events captured during the field testing period. The average rate of I/I within each basin was categorized as high, moderate, or low. The flow meter basins and their respective I/I rates and classifications are shown on **Figure 4-4**. The flow meter basins, SSES priority rankings, discrete I/I rates, and categories of I/I are summarized in **Table 4-7**.

Table 4-7: Summary of I/I Rates by Flow Monitor Basin and Categories of I/I

Flow Monitor ID	WWTP Basin	Basin Priority Ranking	Discrete Basin I/I Rate (Gal/LF/in)	Category
N-05	North	1	12.6	High I/I Greater than 4.0 Gal/LF/in
S-03	South	2	4.18	
S-02	South	3	3.32	Medium I/I 2.0 – 3.9 Gal/LF/in
N-02	North	4	3.29	
N-03	North	5	3.05	
N-01	North	6	2.92	
S-04	South	7	2.59	
N-04	North	8	1.33	Low I/I Less than 2.0 Gal/LF/in
S-01	South	9	0.95	
S-05	South	10	0.66	

4.4 NORTH WWTP SERVICE AREA FLOWS

The observed average day flows based on the temporary ADS flow monitor data at the influent of the North WWTP were considerably higher than the effluent flows captured by the City’s permanent flow monitor. A temporary flow monitor was placed on the effluent of the north WWTP by ADS in April and May of 2017. The data suggested that the five ADS flow monitors installed between November 2016 and February 2017 were over-estimating the North WWTP Service Area flows.

For the purposes of this study, FNI reduced the flow rates from the five flow monitors in the North WWTP Service Area by 30% to more closely align with the temporary ADS effluent flow monitor. This includes flow monitors N-01, N-02, N-03, N-04, and N-05. This flow adjustment is reflected in the hydraulic modeling calibration and analyses and in the wastewater flow projections throughout this study.

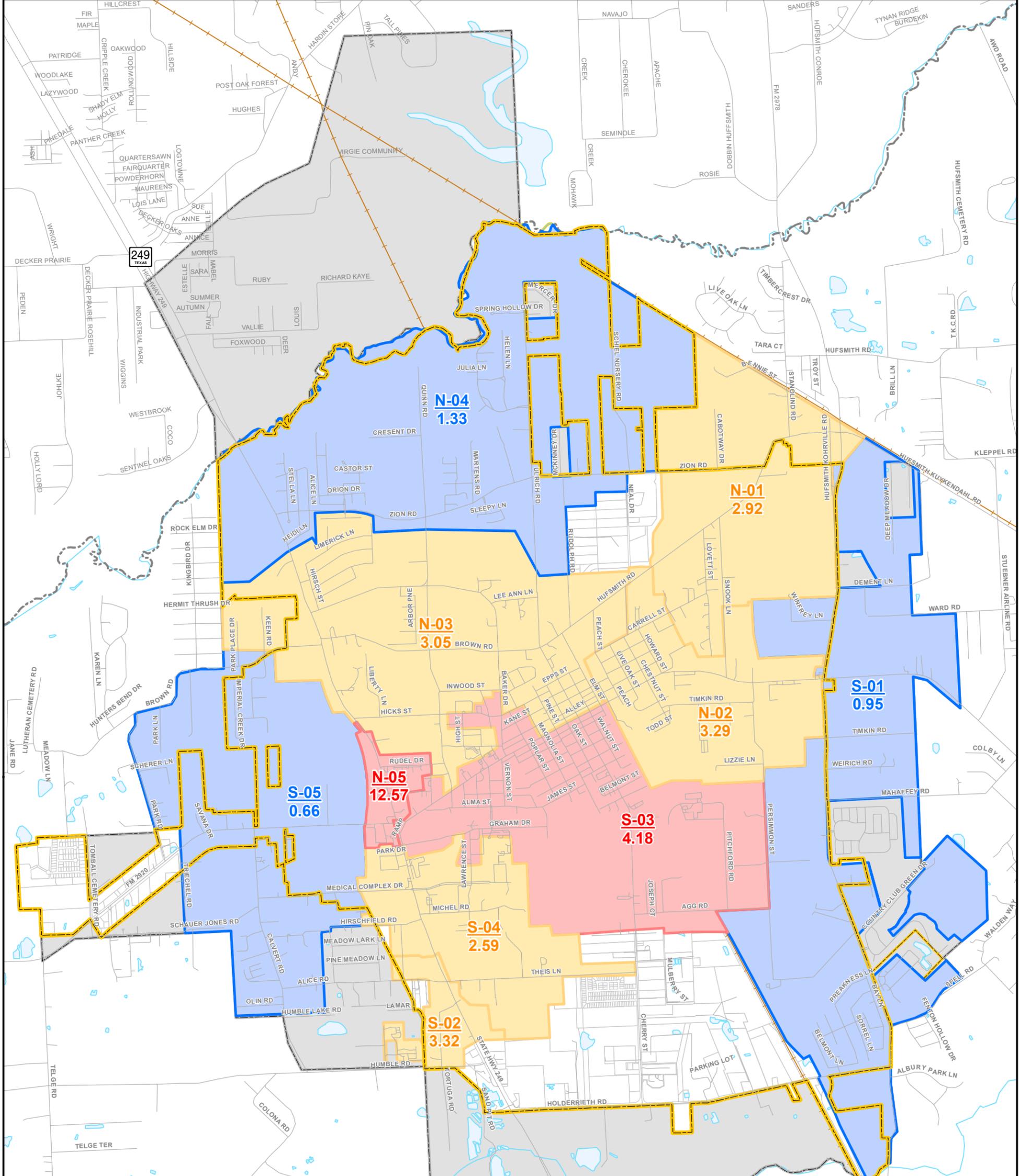
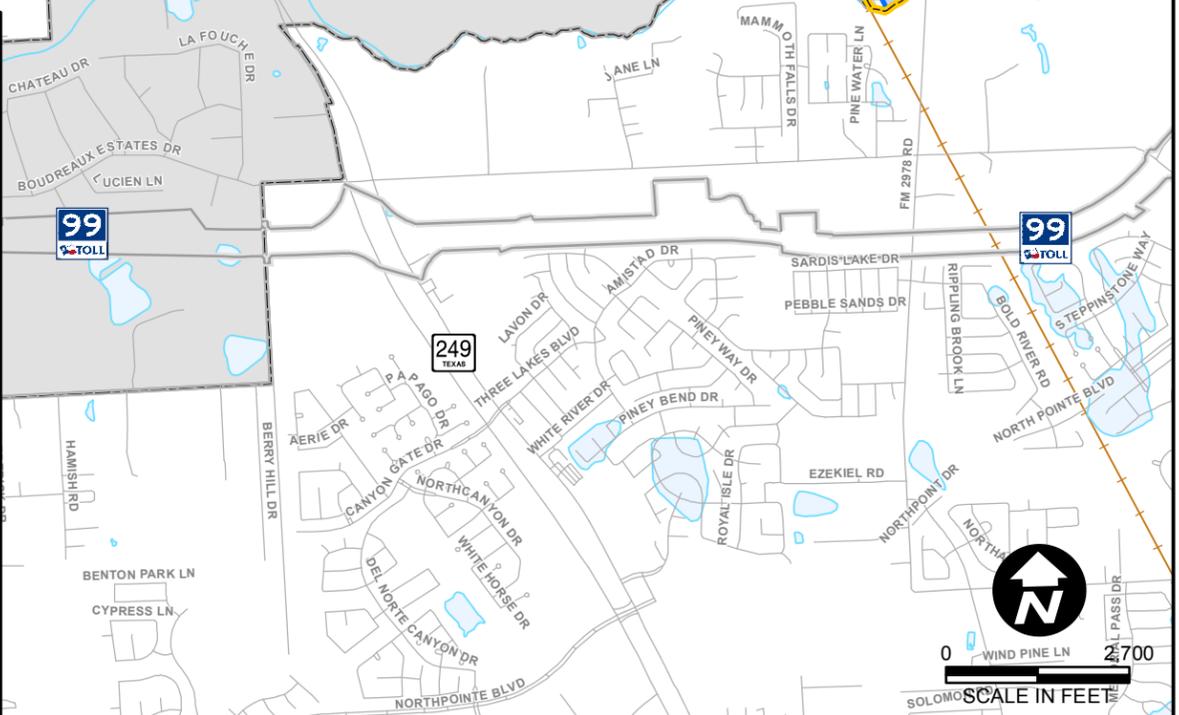


FIGURE 4-4
CITY OF TOMBALL
NORMALIZED I/I BY WASTEWATER BASIN

LEGEND

- Gallons of I/I per LF per inch of rainfall*
- Greater than 4.0 gal/LF/in (High I/I)
 - 2.00 - 3.9 gal/LF/in (Moderate I/I)
 - Less than 2.0 gal/LF/in (Low I/I)
- Flow Monitor ID**
Average I/I
Gal/LF/in
- Parcel
 - Tomball City Limit
 - Tomball ETJ
 - County Line
- Road
 - Railroad
 - Stream
 - Pond/Lake



5.0 WASTEWATER FLOW PROJECTIONS

The performance of Tomball’s collection system is dependent on the amount of water being conveyed through the system currently and in the future. To determine locations where future capacity improvements are necessary, existing flows and future wastewater flow projections must be developed. Tomball’s wastewater flows are generated by residential and commercial sources. Therefore, future per capita residential and per acre commercial wastewater flow projections are critical to the development of short and long-term capital improvements.

FNI developed projected average day and peak wastewater flows for the 5-year, 10-year, and 25-year planning periods for this study. These flows were utilized in the wastewater hydraulic model to plan future wastewater system improvements. Wastewater treatment plants are typically sized for average day flows, while the collection system infrastructure, including lift stations, is sized to convey peak wastewater flows.

5.1 HISTORICAL WASTEWATER FLOWS

Wastewater flows in all municipal collection systems vary by time of day, wastewater discharge source, and weather conditions. Average daily flow (ADF) is defined as the total wastewater flow over a one-year period divided by the number of days in that year. In order to develop wastewater planning criteria and estimate future wastewater flows, historical WWTP flow data was analyzed to determine the historical trends in system-wide average daily flow and per-capita flow.

Historical WWTP effluent average day and 2-Hour peak flows for the North and South WWTP’s were obtained from TCEQ TPDES Discharge Monitoring Reports (DMRs). This data is shown for 2010 – 2016 in **Table 5-1**.

Table 5-1: Historical WWTP Flows

Year	Yearly Rainfall ⁽¹⁾ (in)	North WWTP			South WWTP		
		Average Day Flow ⁽²⁾ (MGD)	2-Hour Peak Flow ⁽²⁾ (MGD)	Peaking Factor	Average Day Flow (MGD)	2-Hour Peak Flow (MGD)	Peaking Factor
2010	36	0.54	3.00	5.6	0.76	2.7	3.6
2011	22	0.49	2.20	4.5	0.80	1.9	2.4
2012	47	0.56	3.80	6.8	0.95	6.2	6.5
2013	45	0.54	3.65	6.8	0.89	5.1	5.7
2014	47	0.55	3.90	7.1	0.88	3.4	3.8
2015	64	0.66	3.50	5.3	0.95	5.6	5.9
2016	49	0.75	5.00	6.6	1.00	6.4	6.3
Average	44	0.58	-	-	0.89	-	-

(1) Rainfall data from Texas Water Development Board (TWDB)

The existing Permitted capacity of each treatment plant is 1.5 MGD of average daily flow. According to the DMRs, the North WWTP has more currently available capacity. The North WWTP has also typically seen higher peaking factors, indicative of large volumes of inflow and infiltration (I/I).

5.2 WASTEWATER PLANNING CRITERIA

Planning criteria for average day wastewater flows for the 5-year, 10-year, and 25-year planning periods in this *Wastewater Master Plan* were developed based on the analysis of historical WWTP flows, water billing records, population, and commercial acreage.

FNI utilized water meter billing data provided by the City to attribute percentages of the total WWTP effluent flow to residential and commercial sources. The City’s population and commercial acreage was then utilized to calculate historical wastewater flows per person (gpcd) and per acre (gpad). This breakdown of historical WWTP flows, populations, and commercial acreages and the resulting gpcd and gpad values is shown in **Table 5-2**.

Table 5-2: Wastewater Planning Criteria Analysis

Year	City Population	Total Wastewater Effluent ⁽¹⁾ (MGD)	Residential		Commercial			Other ⁽⁵⁾ (MGD)
			Residential WW Flow ⁽²⁾ (MGD)	Per Capita WW Flow (gpcd)	Commercial WW Flow ⁽³⁾ (MGD)	Commercial Acreage ⁽⁴⁾ (acres)	Commercial WW Flow (gpac)	
2010	10,753	1.29	0.66	61	0.60	746	802	0.04
2011	10,935	1.29	0.64	59	0.61	746	814	0.04
2012	11,047	1.51	0.79	72	0.67	746	900	0.04
2013	11,117	1.43	0.72	65	0.67	746	904	0.04
2014	11,299	1.43	0.73	65	0.66	746	881	0.04
2015	11,484	1.61	0.82	71	0.74	746	994	0.05
2016	11,672	1.76	0.85	73	0.85	746	1,135	0.06
Average		1.48	0.74	66	0.69		919	0.04
Maximum		1.76	0.85	73	0.85		1,135	0.06

- (1) Combined average daily flows based on North and South Wastewater Treatment Plant TCEQ TPDES Discharge Monitoring Reports.
- (2) The average estimated residential flow percentage based on water meter billing records was 51%
- (3) The average commercial flow percentage based on water meter billing records was 46%
- (4) Commercial Acreage obtained from GIS parcels based on geocoded commercial meters active between Aug 2015 and Dec 2016. 80% of each commercial parcel's acreage was utilized based on the parameters in the City's 2009 Comprehensive Plan.
- (5) Other includes Government and Public facilities

A conservative rate of 90 gpcd was chosen for future residential wastewater flows. A wastewater flow rate of 1,300 gpac was chosen for future commercial acreage. These planning numbers include an allowance for some future I/I as the collection system ages. These average day wastewater flow rate planning criteria are summarized in **Table 5-3**.

Table 5-3: Wastewater Flow Rate Planning Criteria

Wastewater Flow Type	Average Day Wastewater Flow Rate
Residential	90 gpcd
Commercial	1,300 gpac

5.3 PROJECTED WASTEWATER FLOWS

5.3.1 Existing Wastewater Flows

The wastewater flow rates from the flow monitoring were used to establish existing average day dry weather wastewater flows throughout Tomball's collection system, utilizing the 10 flow monitor basins.

Existing peak flows associated with the selected design storm were developed in the calibrated hydraulic model during the existing system analysis. Population within each flow monitor basin was calculated based on the geocoded residential water meter locations and 2.6 persons per dwelling unit identified in the City’s 2009 *Comprehensive Plan*. Commercial acreages were based on geocoded commercial water meters and GIS parcel data. The water meter geocoding and existing system analysis are discussed in **Section 6.0** and **Section 7.0**, respectively. The existing average day wastewater flows, peak wet weather flows, populations, and commercial acreage within each flow monitor basin are summarized in **Table 5-4**.

Table 5-4: Existing Wastewater Flows

	Flow Monitor Basin	Population	Commercial Acreage (ac)	Average Day Dry Weather Flow ⁽¹⁾ (MGD)	Peak Flow ⁽²⁾ (MGD)
North WWTP	N-01	864	16.0	0.03 ⁽³⁾	0.43
	N-02	806	97.8	0.18 ⁽³⁾	2.08
	N-03	3,071	163.8	0.30 ⁽³⁾	2.51
	N-04	2460	177.2	0.11 ⁽³⁾	0.99
	N-05	262	46.4	0.08 ⁽³⁾	0.81
	Unmetered	13	5.9	-	-
	North Basin Subtotal	7,476	507	0.71⁽³⁾	-
South WWTP	S-01	0	43.7	0.01	0.87
	S-02	1,854	23.6	0.03	0.42
	S-03	1,248	251.1	0.41	2.47
	S-04	596	163.4	0.29	1.16
	S-05	231	83.6	0.13	0.38
	Unmetered	458	74.5	0.04 ⁽⁴⁾	-
	South Basin Subtotal	4,387	640	0.90	-
Total	11,863	1,147	1.61	-	

(1) Average day, discrete dry weather basin flows from flow monitoring

(2) Peak flows based on calibrated model design storm analysis

(3) Reduced by 30% based on temporary ADS effluent flow monitor installed at the North WWTP from April - May 2017

(4) Average Day Flow based on existing population and 90 gpcd

5.3.2 Projected Wastewater Flows

FNI developed future average day and peak wastewater flows for each flow monitor basin for the 5-year, 10-year, and 25-year planning periods. The existing average day and peak flows were held constant throughout all planning periods.

Future average day wastewater flows were calculated within each flow monitor basin by applying the selected planning criteria in **Table 5-3** only to the growth in population and increase in commercial acreage identified in **Section 2.3**. Future peak wastewater flows were calculated using a peak flow to average day peaking factor of 4.0. The future average day and peak flows were then added to the existing flows to develop the projected future wastewater flows. **Table 5-5** summarizes the projected average day and peak wastewater flows per flow monitor basin within the North and South WWTP service areas.

5.3.3 WWTP Service Area Flows

The total projected average day wastewater flows within each WWTP Service Area in each planning period are graphed on **Figure 5-1** and **Figure 5-2**.

75/90 Rule

Figure 5-1 and **Figure 5-2** each include three lines showing the **permitted average day flow (ADF) capacity of the WWTP**, **90% of the permitted ADF capacity**, and **75% of the permitted ADF capacity**. These are based on TCEQ §305.126, commonly referred to as the 75/90 rule, which requires a WWTP permit holder to begin planning for expansion of the treatment facility when the average day or average annual flow reaches 75% of the permitted capacity for three consecutive months. When the average day or average annual flow reaches 90% of the permitted capacity, the permit holder shall obtain necessary authorization from the Commission to commence construction of the necessary additional treatment facilities.

WWTP Capacity Evaluation

The projected average day wastewater flows show that additional WWTP capacity will be needed within the 25-year planning period of this study. WWTP capacity and other analyses is discussed further in **Section 8.0**.

Table 5-5: Projected Wastewater Flows

Flow Monitor Basins	2017				2022				2027				2042				
	Total Population	Total Commercial Acreage (ac)	Average Day Dry Weather Flow ⁽¹⁾ (MGD)	Peak Flow ⁽²⁾ (MGD)	Total Population	Total Commercial Acreage (ac)	Average Day Flow ⁽³⁾ (MGD)	Peak Flow ⁽⁴⁾ (MGD)	Total Population	Total Commercial Acreage (ac)	Average Day Flow ⁽³⁾ (MGD)	Peak Flow ⁽⁴⁾ (MGD)	Total Population	Total Commercial Acreage (ac)	Average Day Flow ⁽³⁾ (MGD)	Peak Flow ⁽⁴⁾ (MGD)	
North WWTP	N-01	864	16.0	0.03 ⁽⁵⁾	0.43	871	15.97	0.03	0.43	871	15.97	0.03	0.43	1391	31.0	0.09	0.68
	N-02	806	97.8	0.18 ⁽⁵⁾	2.08	806	97.8	0.18	2.08	806	97.9	0.18	2.08	806	97.9	0.18	2.08
	N-03	3,071	163.8	0.30 ⁽⁵⁾	2.51	3,193	163.8	0.31	2.56	3,322	186.5	0.35	2.70	3,322	198.0	0.36	2.75
	N-04	2460	177.2	0.11 ⁽⁵⁾	0.99	4906	177.2	0.33	1.87	4968	179.5	0.34	1.91	4968	179.5	0.34	1.91
	N-05	262	46.4	0.08 ⁽⁵⁾	0.81	262	46.4	0.08	0.81	262	48.5	0.08	0.81	262	48.5	0.08	0.81
	Unmetered	13	5.9	-	-	13	0	0.00	0.00	13	-	-	-	13	-	-	-
	North Subtotal	7,476	507	0.71⁽⁵⁾	-	10,051	501	0.94	-	10,242	528	0.99	-	10,762	555	1.06	-
South WWTP	S-01	0	43.7	0.01	0.87	0	51.9	0.02	0.90	956	65.2	0.12	1.30	1,681	155.0	0.28	1.94
	S-02	1,854	23.6	0.03	0.42	1,854	23.6	0.03	0.42	1,854	35.5	0.04	0.47	1,854	35.5	0.04	0.47
	S-03	1,248	251.1	0.41	2.47	1,248	251.1	0.41	2.47	1,248	270.6	0.43	2.55	1,248	270.6	0.43	2.55
	S-04	596	163.4	0.29	1.16	596	165.9	0.29	1.17	596	182.9	0.31	1.24	945	182.9	0.34	1.37
	S-05	231	83.6	0.13	0.38	231	83.6	0.13	0.38	231	83.6	0.13	0.38	231	117.6	0.16	0.52
	Unmetered	458	74.5	0.04	-	458	74.5	0.04	-	599	119.7	0.10	-	2,742	139.6	0.31	-
	South Subtotal	4,387	640	0.90	-	4,387	651	0.91	-	5,484	757	1.12	-	8,701	901	1.56	-
Total	11,863	1,147	1.61	-	14,438	1,152	1.85	-	15,726	1,286	2.11	-	19,463	1,456	2.62	-	

(1) 2017 discrete basin dry weather flows from flow monitoring

(2) 2017 Peak flows based on calibrated model design storm analysis

(3) Future Average Day Flow computed using planning criteria: Future Residential Flows = 90 gpcd; Future Commercial Flows = 1,300 gpad

(4) Future Peak Flow computed using a peaking factor of 4.0

(5) Reduced by 30% based on temporary ADS effluent flow monitor installed at the North WWTP from April - May 2017

Figure 5-1: Projected Average Day Wastewater Flows (North WWTP Service Area)

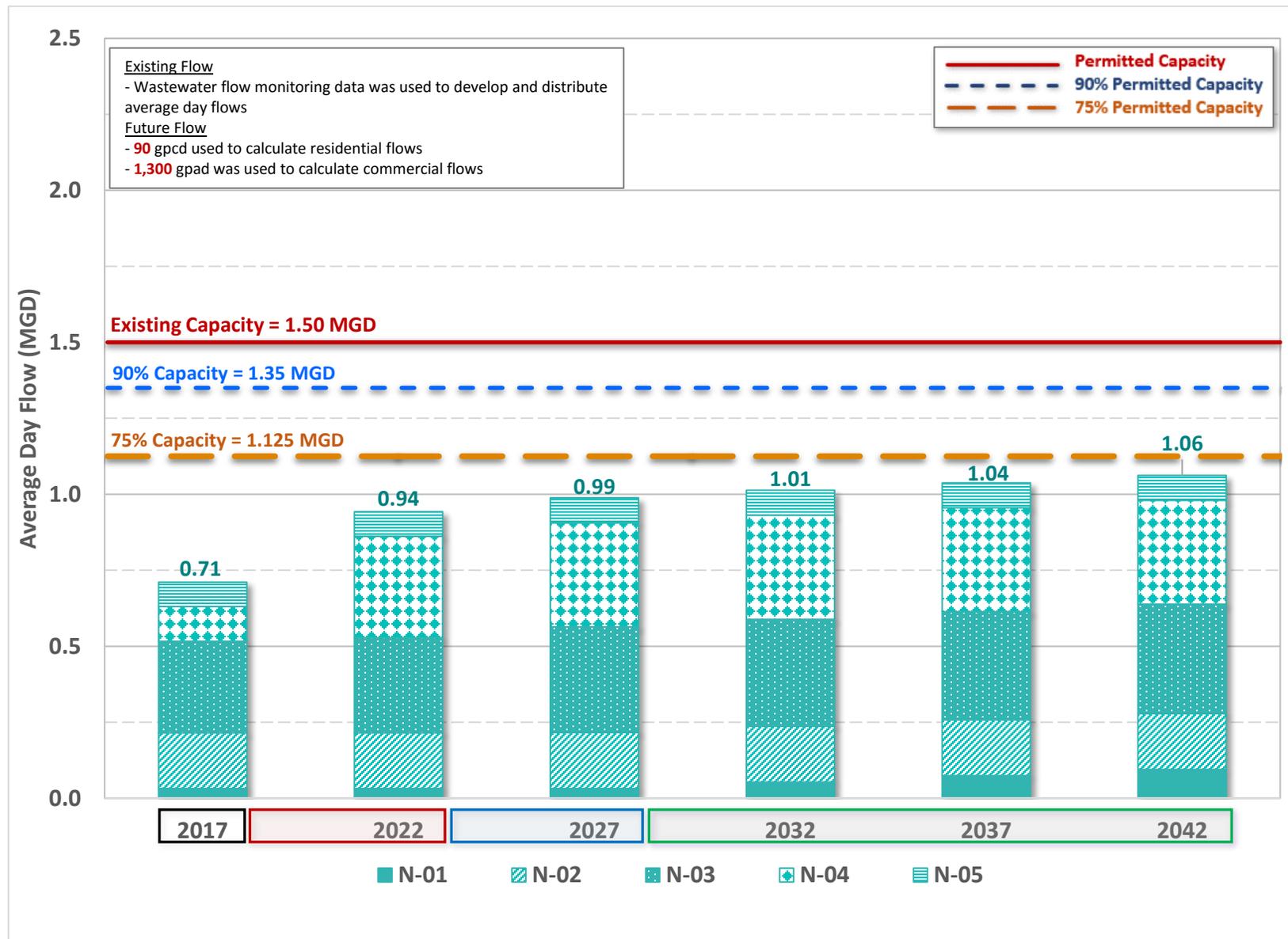
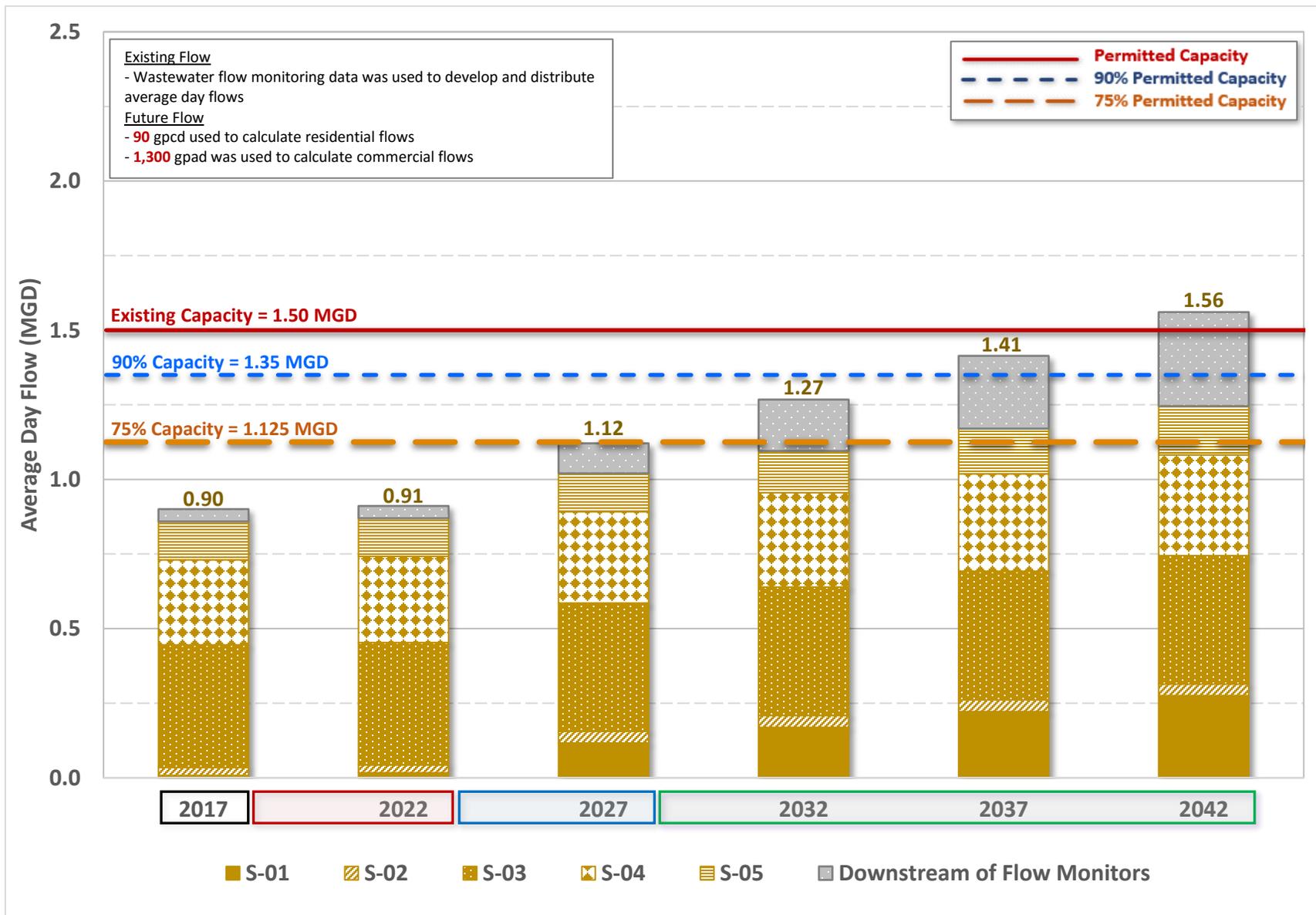


Figure 5-2: Projected Average Day Wastewater Flows (South WWTP Service Area)



6.0 WASTEWATER MODEL DEVELOPMENT AND CALIBRATION

The InfoSewer® modeling software by Innovyze® was selected as the hydraulic modeling software for this project. InfoSewer® has dynamic modeling capabilities as well as GIS interoperability. These features allow for more realistic flow representation over time and the ability to maintain relationships between the modeled wastewater assets and those in the City’s GIS database. FNI built and calibrated the hydraulic wastewater model to serve as a basis for all existing and future system analysis modeling scenarios and CIP development.

6.1 MODELED NETWORK AND DATA VALIDATION

In this study, all gravity wastewater lines with diameters of 10 inches or larger were included in the model. Key 8-inch lines were included for connectivity and for modeling portions of the downtown Tomball gravity main network. The model consists of approximately 721 links and 727 nodes, including 3 outfalls, 7 lift stations, and 14 pumps. Approximately 178,700 feet (34 miles) of gravity wastewater line within the City’s collection system is included in the wastewater model.

The basis of the wastewater model was the City’s GIS database. The City provided FNI with GIS shapefiles of the collection system components (lift stations, gravity lines and force mains). These shapefiles were imported into the modeling software and the wastewater network was reviewed for proper connectivity. Pipes were reviewed to check for missing invert levels and diameters, and manholes were reviewed to check for missing ground levels (manhole rim elevations) and diameters.

The wastewater model includes the following recently completed sewer projects:

- **Medical Complex Drive 12/15-inch sanitary sewer line expansion**
- **Raleigh Creek Subdivision 350 gpm (firm capacity) Lift Station and 6-inch Force Main**
- **10-inch sanitary sewer line along Hwy 249 between Hicks Street and Baker Drive**

6.2 COLLECTION SYSTEM UNIQUE IDENTIFIERS (IDs)

The Tomball GIS did not have a unique ID for each collection system component. Unique IDs are required by modeling software and a best practice for maintaining and updating utility system assets in a GIS database. FNI created and assigned unique IDs for all modeled wastewater system assets (manholes, gravity lines, and force mains). The unique IDs were assigned to each element during the model build process. The format of the unique IDs is shown in **Table 6-1**.

Table 6-1: Format of Unique IDs for Wastewater Collection System Components

Wastewater System Component	Unique ID Format
Manholes	MH_###
Gravity Main	SS_###
Force Main	FM_Lift Station Name_#

6.3 WASTEWATER SYSTEM FIELD DATA COLLECTION

Field data collection was performed by City staff at six manholes and three lift stations in the collection system (Sherwood, Snook Lane, and FM2920 & Park Rd). This survey and data collection effort was performed at locations where the City’s GIS database was missing invert or elevation information or contained conflicting invert data. FNI developed field data collection forms for the manhole measure downs. Data collected at sewer manholes and lift stations included:

- Manhole diameter and Rim elevation above ground
- Measure downs to inverts of all incoming and outgoing lines
- Diameter, depth and direction of all incoming and outgoing lines
- Manhole material and general condition
- Wet well depth and depths to all incoming sewer line inverts

The results of the field data collection were incorporated into the wastewater hydraulic model. The field data collection forms, along with the wet well depth and invert information, are included in **Appendix F**.

6.4 NETWORK DEVELOPMENT AND INFORMATION FLAGGING

FNI created information flags in the wastewater model during network review and development. These information flags indicate the source of the information used to populate the model component data fields such as pipe diameter, manhole rim elevation, etc. A summary of the information flags utilized in the Tomball wastewater model are listed in **Table 6-2**. These flags are discussed further in the following sections. All information from the City’s GIS shapefiles was flagged as [TGIS].

Table 6-2: Wastewater Model Information Flags

Information Flag	Description
TGIS	Tomball GIS
SRV	Field Collected/Verified Data
AB	As Built Drawings / Plans
CONT	2-foot Ground Elevation Contours
INT ⁽¹⁾	Interpolation
SFT	Shift Due to Local Datum Adjustment
CS	Information from City Staff
VI	Information from Pump Vendors
FNI ⁽¹⁾	FNI Modified Data

(1) The INT and FNI flags was used for multiple reasons; see usage-specific explanations in **Sections 6.4.1, 6.4.2, and 6.4.3**

6.4.1 Manholes

Rim Elevations

Missing rim elevations were populated using the following data sources and assigned the following information flags, listed in brackets [Information Flag]:

- As-Built Drawings/Plans [AB]
- 2-foot contours [CONT]
- Interpolation based on adjacent/nearby manholes [INT]
- Datum shifted data (due to local elevation datums used in drawings) [SFT]

Manhole Diameters

Missing manhole diameters were populated using the following data sources and assigned the following information flags, listed in brackets [Information Flag]:

- As-Built Drawings/Plans [AB]
- Incoming/outgoing gravity line diameters [FNI]

LocationS

The sewer manhole GIS shapefile from Tomball had a field named *LocationS* that contains source information populated by the City. The entries were ‘AsBuilt’, ‘TBNCAD’, and ‘CTOM’. This information was preserved in the wastewater model and assigned the [TGIS] information flag.

6.4.2 Wastewater Lines and Force Mains

Line Diameters

Missing gravity line and force main diameters were populated using the following data sources and assigned the following information flags, listed in brackets [Information Flag]:

- As-Built Drawings/Plans [AB]
- Associated/nearby line diameters [FNI]

Inverts

Missing gravity line inverts were populated using the following data sources and assigned the following information flags, listed in brackets [Information Flag]:

- As-Built Drawings/Plans [AB]
- Field collected data, based on ADS manhole depths and City staff measure-downs [SRV]
- Interpolation between known inverts [INT]
- Minimum slope based on TCEQ criteria, associated/nearby invert information [FNI]
- Datum shifted data (due to local elevation datums used in drawings) [SFT]

The [FNI] information flag for inverts includes the assignment of minimum slopes based on the TCEQ minimum slope criteria. The Texas Commission on Environmental Quality (TCEQ) requirements for minimum slopes are provided below in **Table 6-3**.

Table 6-3: TCEQ Minimum Slope Requirements

Pipe Size ⁽¹⁾ (in)	Minimum Slope (ft/ft)	Maximum Slope (ft/ft)
6	0.00500	12.35
8	0.00335	8.40
10	0.00250	6.23
12	0.00200	4.88
15	0.00150	3.62
18	0.00115	2.83
21	0.00095	2.30
24	0.00080	1.93
27	0.00070	1.65
30	0.00060	1.43
33	0.00055	1.26
36	0.00045	1.12
39	0.00040	1.01
> 39 ⁽¹⁾	-	-

(1) For pipes larger than 39 inches in diameter, the slope is determined by Manning’s formula to maintain a velocity greater than 2.0 feet per second and less than 10.0 feet per second when flowing full.

Material

The GIS shapefile for the wastewater lines contained material information on approximately 29% of the lines. No additional information was available or added to the wastewater line material field for the remaining 71% of lines in the model. These fields were left blank.

Notes

The wastewater line GIS shapefile from Tomball had a field named *Notes* that contained information on the City’s as-built plans and construction drawing numbers. This information was populated for the *Medical Complex Drive 12-inch Sanitary Sewer Expansion* project, and was flagged as [FNI].

Locations

The wastewater line GIS shapefile from Tomball had a field named *LocationS* that contains source information populated by the City. The entries were ‘AsBuilt’, ‘TBNCAD’, and ‘CTOM’. This information was preserved in the wastewater model and assigned the [TGIS] information flag.

A Manning’s roughness coefficient of 0.013 was assigned to all gravity lines in the hydraulic model. A Hazen-Williams C-Factor of 100 was used for all force mains in the model.

6.4.3 Lift Stations

FNI input lift stations and force mains into the model based on GIS data, construction drawings, and information from the City's field data collection.

Pump Capacities

Pumping capacities were input into the model based on the following data sources and assigned the following information flags, listed in brackets [Information Flag]:

- Pump curve or design points obtained from As-Built Drawings/Plans [AB]
- Information from City Staff [CS]
- Pump curves obtained from pump vendors [VI]
- Model assumption [FNI]

Force mains were input to the model along the general routes identified in the GIS files and construction drawings. High points along the force main routes were located using a triangulated irregular network (TIN) surface developed from 2-ft contours and entered in the model. This process was performed so that the modeled pumps would experience the head conditions seen by the pumps at the actual lift stations.

Three of the City's lift stations are located on 10-inch or larger gravity lines and were included in the hydraulic model. An additional 5 lift stations were included in the model due to service area, firm capacity and/or proximity to larger diameter sewer lines. The 8 modeled lift stations are shown in **Table 6-4**.

The remaining three lift stations have small service areas and corresponding assumed small firm pumping capacities. The residential and commercial flows generated within these lift station service areas were included in the hydraulic model; however, the lift stations were not modeled. The non-modeled lift stations are shown in **Table 6-5**.

Table 6-4: Modeled Lift Stations

WWTP Service Area	Lift Station Name (No.)	Firm Capacity ⁽¹⁾ (gpm)	Flag
North	North Star Estates (No. 1)	150 ⁽²⁾	FNI
	Sherwood Forest (No. 2)	300	VI
	Hunterwood (No. 3)	112	AB
	Snook Lane (No. 4)	115 ⁽²⁾	FNI
	Tomball Hills (No. 5)	410	AB
	Hicks St. (No. 10)	440	AB
	Raleigh Creek ⁽³⁾ (No.11)	350	AB
South	FM 2920 (No. 9)	325	CS

(1) All of the City’s lift stations are duplex lift stations. All lift stations are assumed to have identical pumps. The firm capacity of a duplex lift station with identical pumps is defined as the maximum flow rate achievable, under design conditions, with one pump out of service.

(2) Modeling assumption; manufacturer data unavailable

(3) The Raleigh Creek Lift Station is not currently part of the City’s collection system. It was included in the model due to its firm capacity and proximity to the North WWTP.

Table 6-5: Non-Modeled Lift Stations

WWTP Service Area	Lift Station (No.)	Firm Capacity ⁽¹⁾ (gpm)
North	Persimmon (No. 6)	<i>Unknown</i>
	Jergens Park (No. 7)	<i>Unknown</i>
	Matheson Park (No. 8)	<i>Unknown</i>

6.4.4 Subbasin Area

InfoSewer® stores hydrologic runoff information important to wet weather calibration in a manhole attribute field called ‘Subbasin Area’. This represents the physical land area (in acres) that contributes runoff to the wastewater system. FNI developed a subbasin area for each manhole in the wastewater system that was adjusted during the wet weather calibration.

6.5 DRY WEATHER FLOW ALLOCATION

FNI allocated wastewater loads to the hydraulic model using the geocoded water customer billing account information provided by the City. The active water meters were spatially located in GIS and joined to the parcel shapefile based on the customer address. GIS tools were used to determine the manhole to which

each water meter and corresponding building would drain, and a water consumption was then applied to the hydraulic model at these manholes. The water consumption input to the model was a winter average of the billed water consumption from the months of November 2015 – January 2016. This average was utilized to remove irrigation water from the consumption data.

6.6 DRY WEATHER CALIBRATION

Dry weather calibration is conducted so that the hydraulic model closely matches observed dry weather flows. These dry weather flows represent residential, commercial, and groundwater flows during a period without any additional measurable I/I due to rainfall. FNI chose a five-day period from December 12th to December 16th, 2016 for the dry weather calibration.

Diurnal patterns for each flow monitor basin were loaded into the model based on the patterns observed during the flow monitoring period. The water consumption was then factored as necessary to reflect wastewater return rates and groundwater sources until the dry weather average day wastewater flows in each basin closely matched the observed flow monitor data. The standard for dry weather average day flow calibration is +/- 5%, and this was achieved for the average daily flows at each of the 10 flow monitor sites. Plots demonstrating the dry weather model calibration results are provided in **Appendix G**.

6.7 WET WEATHER CALIBRATION

Wet weather calibration builds upon the dry weather calibration and is performed so that the model closely matches observed wet weather flows. These wet weather flows represent the sum of the dry weather flows plus the additional I/I that enters the wastewater system during a rainfall event. FNI chose the observed storm event from January 2nd, 2017 for the wet weather calibration. The total rainfall from this storm event was approximately 1.95 inches. This rainfall event had the highest observed high peak intensity during the field data collection period.

FNI utilized the RTK hydrograph method to model the additional flows that entered the wastewater system during the observed calibration storms. This method utilizes three hydrographs that each contain three parameters which are modified to achieve calibration: flow of water into the system (R), the time to peak flow (T), and the ratio of time until normalization of flow to time to peak (K). The combination of the three component hydrographs form the total response (additional I/I) that is observed in the wastewater system. The RTK parameters and the component hydrographs are illustrated on **Figure 6-1** and

Figure 6-2.

Figure 6-1: RTK Parameters

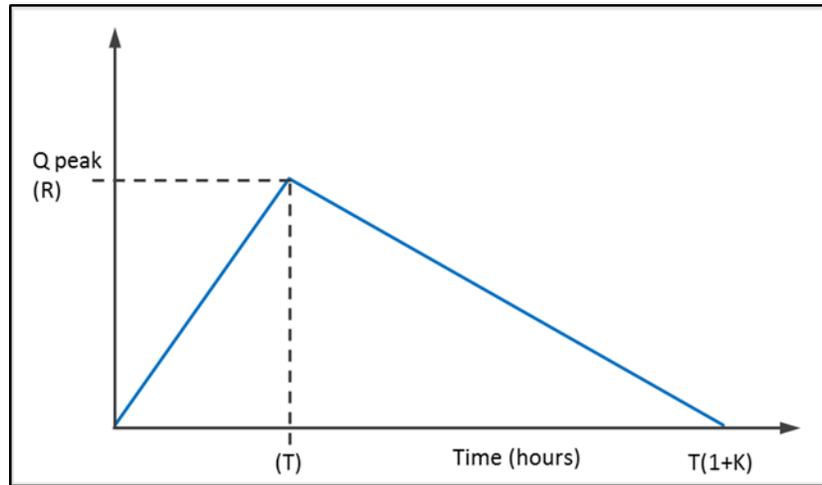
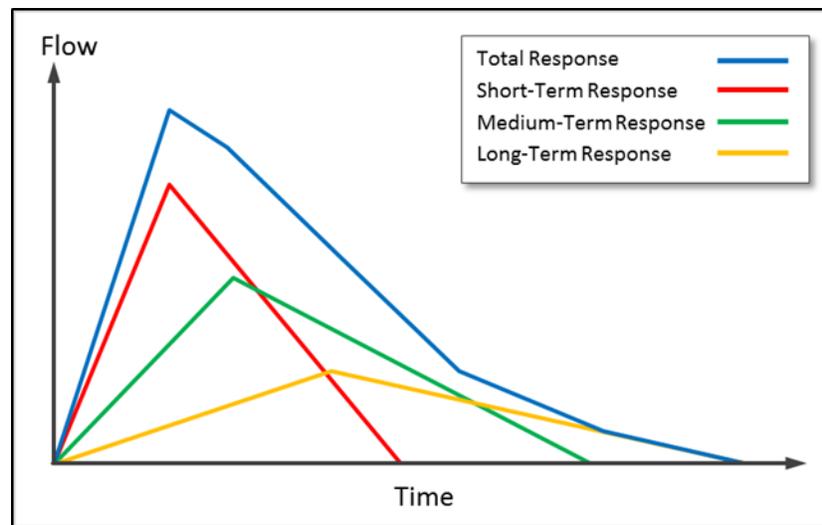


Figure 6-2: RTK Component Hydrographs



Separate RTK hydrographs were developed for each wastewater basin to account for the different land uses, soil properties, amounts of impervious cover, and condition of the wastewater lines in each basin. In the InfoSewer[®] model, the RTK hydrographs were applied to the subbasin area in each wastewater subbasin. The observed rainfall hyetographs measured during the calibration rainfall events were then applied to the model. The model calculates the I/I that enters the wastewater system using the values in the RTK hydrographs and the subbasin area of each manhole. The RTK parameters, along with the subbasin areas, were adjusted until the modeled wet weather flows closely matched the observed wet weather flows. The standard for wet weather calibration is +/- 10% of the observed peak flows, and this

was achieved at each of the 10 flow monitor sites. Plots demonstrating the wet weather model calibration results are also provided in **Appendix G**.

Calibration Results

The dry and wet weather calibration results provide confidence that the model closely matches real world conditions and suitable to use for hydraulic analyses and CIP development. The model is calibrated well within industry standards.

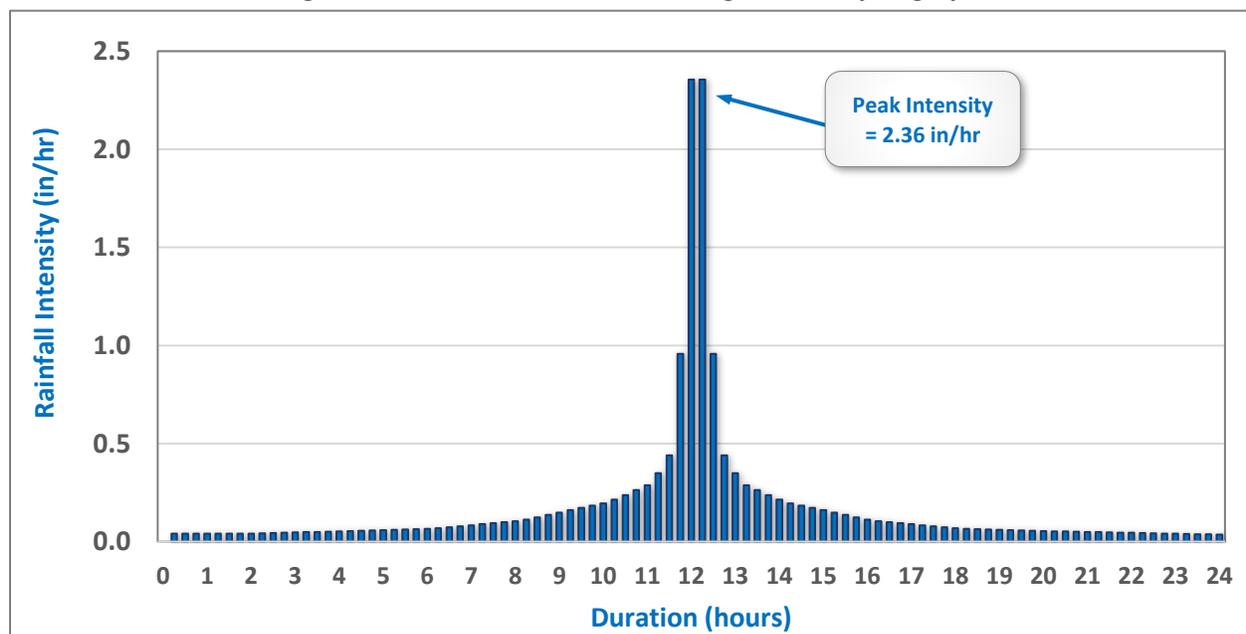
7.0 HYDRAULIC MODELING AND WASTEWATER SYSTEM ANALYSES

Hydraulic analyses were conducted to identify deficiencies in the City’s existing wastewater collection system and establish a capital improvements plan to address deficiencies in the existing system and accommodate the projected wastewater flows through 2042. Various combinations of improvements and modifications were investigated to determine the most appropriate approach for conveying projected flows. Considerations in developing the CIP included increasing system reliability, simplifying system operations, conveying peak wet weather flows, and reducing surcharging and sanitary sewer overflows.

7.1 DESIGN STORM

A 2-year 24-hour design storm was utilized for the existing and future system analyses. This design storm is commonly used in Texas and provides a reasonable balance between level of service and wastewater infrastructure cost. The rainfall depth and intensity of the 2-year 24-hour storm was determined using historical storm event data for the region of Tomball. The historical data was analyzed and summarized in the *United States Geological Survey (USGS) Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*. The 2-year, 24-hour design storm for the City of Tomball is a 4.1-inch rainfall event. The shape of the design storm hyetograph (rainfall vs. time) was developed using the NRCS (SCS Type III) method. The 2-year, 24-hour design storm hyetograph used for system analyses is shown on **Figure 7-1**.

Figure 7-1: 2-Year, 24-Hour Design Storm Hyetograph



7.2 EXISTING WASTEWATER SYSTEM ANALYSES

The critical flow condition for analyzing a wastewater collection system is peak wet weather. Flow, depth, and velocity are important factors when analyzing the peak wet weather simulations. When the design storm is applied to the calibrated model, the effects of I/I in the system can be seen. As the storm intensifies (shown through time on **Figure 7-1**), additional flow enters the system. The model determines the point in time at which the amount of water from the design storm event reaches the peak within the system. This peak represents the most taxing load the system experiences under the design storm event.

7.2.1 Existing System Model Results

Figure 7-2 displays a color-coded map illustrating the surcharged state of modeled lines and manholes under the existing peak conditions of a 2-year, 24-hour design storm event (4.1 inches) for the City of Tomball. The **orange lines** indicate 80-99% of the capacity in the line is being utilized to convey the modeled design storm peak flows. The **red lines** indicate surcharging. This can occur due to a lack of capacity in that gravity line segment or a downstream restriction (i.e. insufficient lift station pumping or insufficient capacity in a downstream line). Locations where the predicted maximum hydraulic grade line (HGL) rises to within 3 feet of the manhole rim are shown as **yellow circles** on the map. The locations of predicted sanitary sewer overflows as a result of the modeled 2-year 24-hour design storm are shown as **red circles** on the map.

The following areas of the existing collection system were identified as having capacity constraints:

North WWTP Service Area

- The hydraulic model indicated surcharging in the 15-inch line along North Willow Street under the modeled 2-year 24-hour design storm peak flows. This is due to inadequate capacity in these line segments.
- The 20-inch sanitary sewer along Hufsmith Road is approaching its maximum conveyance capacity under the modeled 2-year 24-hour design storm peak flows.
- The calibrated model indicated surcharging upstream of the Hicks Lift Station under the modeled 2-year 24-hour design storm peak flows. This is due to the large volume of I/I and the firm capacity of the Hicks Lift Station.

South WWTP Service Area

- The hydraulic model indicated surcharging in the 8-inch lines along Alma Street and James Street under the modeled 2-year 24-hour design storm peak flows. This is due to inadequate capacity in these lines.
- The hydraulic model indicated surcharging in the 10-inch lines along Michel Road under the modeled 2-year 24-hour design storm peak flows. Additionally, the 10-inch lines along Medical Complex and Tomball Pkwy were shown to be approaching their maximum conveyance capacity. These observations are due to the capacity of these line segments.
- Under the 2-year 24-hour design storm peak flows, the model indicated surcharging to within three feet of the manhole rim as well as predicted overflows at manholes along FM 2920 near the FM 2920 & Park Road Lift Station. This is due to the firm capacity of the lift station.

Additional Survey

There are gravity line segments around Baker Drive and downstream of the Sherwood Lift Station that were shown to be **red** (lacking conveyance capacity) in the hydraulic model. The flow capacity for all gravity sewer lines is calculated based on the inverts and resulting slope. It should be noted that invert information for these line segments around Baker Drive was unavailable and interpolated inverts were assumed in the model. Therefore, it is not recommended that infrastructure projects be implemented at this location. Until these lines can be surveyed to check the accuracy of the inverts in the model.

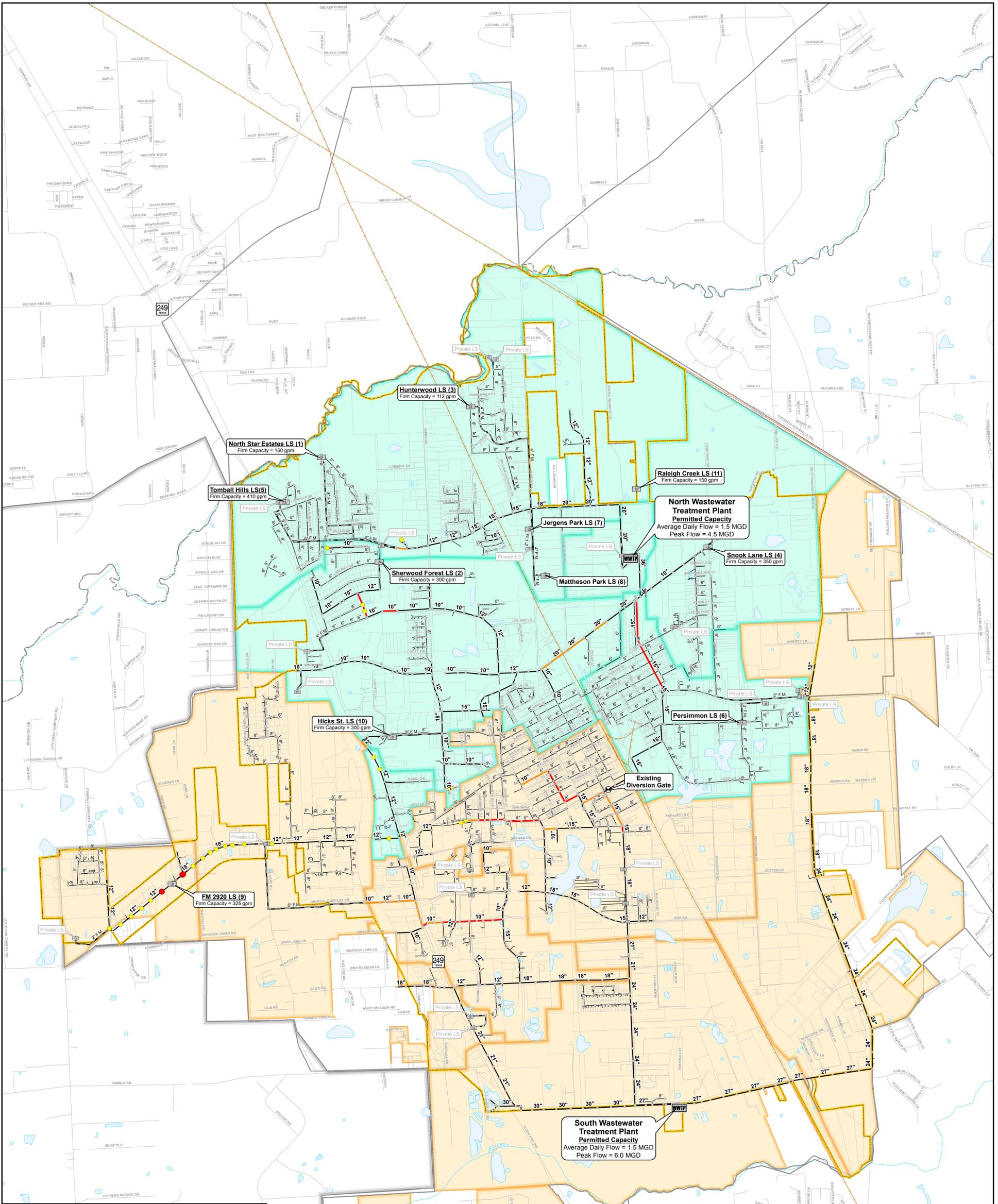


FIGURE 7-2
CITY OF TOMBALL
EXISTING SYSTEM ANALYSIS

LEGEND

- | | |
|------------------------------------|--------------------------------|
| Manhole Results | Wastewater Line Results |
| ○ Manhole | — q/Q 0.80 - 0.99 |
| ● Surcharged within 3-ft of MH Rim | — q/Q Greater than 1 |
| ● Predicted Overflow | — Road |
| ⊗ Diversion Gate | — Railroad |
| ⊠ Lift Station | — Stream |
| ⊠ Private Lift Station | — Lake |
| ⊠ Wastewater Treatment Plant | — Parcel |
| — 8" and Smaller Wastewater Line | — Tomball City Limit |
| — 10" and Larger Wastewater Line | — Tomball ETJ |
| — 8" and Smaller Force Main | — Houston ETJ |
| — 10" and Larger Force Main | — County Boundary |

WASTEWATER BASIN

- North Basin
- South Basin



Created By: P. Jones 06/10/2010
 Date: 11/11/2010
 Location: H:\10_WW_PLANNING\DELIVERABLES\FINAL_REPORT\Figures_7-2_Existing_System_Analysis.mxd
 User: P. Jones, October 11, 2010 12:15:18 PM

0 1,400' 2,800'

SCALE IN FEET

7.3 FUTURE WASTEWATER SYSTEM ANALYSES

FNI conducted hydraulic analyses to establish a capital improvements plan to convey the projected peak wastewater flows through 2042.

7.3.1 Design Criteria for Gravity Lines

When determining the size of proposed wastewater lines, TCEQ provides specific design criteria. TCEQ §217.53 (l)(1) dictates that collection systems must be designed to maintain a minimum velocity of 2 feet/second. Maintaining these velocities discourages the settling of solids. In accordance with this, TCEQ has established minimum slope guidelines in §217.53 (l)(2)(A). These are shown in **Table 6-3**.

Additionally, TCEQ §217.53 (j)(3) states “An owner must ensure that the collection system has capacity to prevent a surcharge.” Proposed developer wastewater lines consider the TCEQ minimum slope criteria, and the recommended wastewater lines are sized to convey the projected peak 2-Year 24-Hour design storm flows without surcharging conditions.

7.3.2 Design Criteria for Lift Stations and Force Mains

TCEQ design criteria §217.61 (c) states “The firm pumping capacity of a lift station must handle the peak flow.” Firm pumping capacity is defined as the maximum pumping capacity with the largest pumping unit out of service. TCEQ §217.67 (a) also states that force mains shall be sized to convey the lift station pumping capacity at a minimum velocity of 3 feet/second for duplex lift stations and 2 feet/second with one pump operating at a lift station with three or more pumps. Recommended lift station firm pumping capacities and force main sizes are based on these TCEQ criteria.

At lift stations where expansion in firm pumping capacity is recommended, the existing wet wells were evaluated for capacity based on the TCEQ minimum pump cycle times. These cycle times are listed in **Table 7-1**.

Table 7-1: TCEQ Minimum Pump Cycle Times

Pump Horsepower	Minimum Cycle Times (minutes)
< 50	6
50 – 100	10
> 100	15

7.3.3 Existing System Model Results under 2042 Peak Flows

FNI created future hydraulic model scenarios to analyze needed capital improvements. These scenarios added the projected peak wastewater loads for each planning period to the existing system. This approach shows what improvements are needed in each of the three CIP planning periods (2022, 2027, and 2042). **Figure 7-3** displays the modeled results of the 2-year 24-hour design storm with projected 2042 flows on the existing wastewater system. Gravity lines and manholes are color coded **orange, yellow** and **red** as discussed in **Section 7.2.1**. The following areas of concern were identified (in addition to the existing system issues discussed in **Section 7.2**).

North WWTP Service Area

- The 20-inch gravity line along Hufsmith Road is predicted to become surcharged due to projected development in the N-03 basin. Additionally, the model is predicting the 15-inch lines along the drainage ditch near the intersection of Hufsmith Road and Baker Drive to be approaching their maximum conveyance capacity.

South WWTP Service Area

- The peak flows from projected development in the South WWTP Service Area resulted in additional capacity restrictions at each of the areas noted in **Section 7.2.1**.

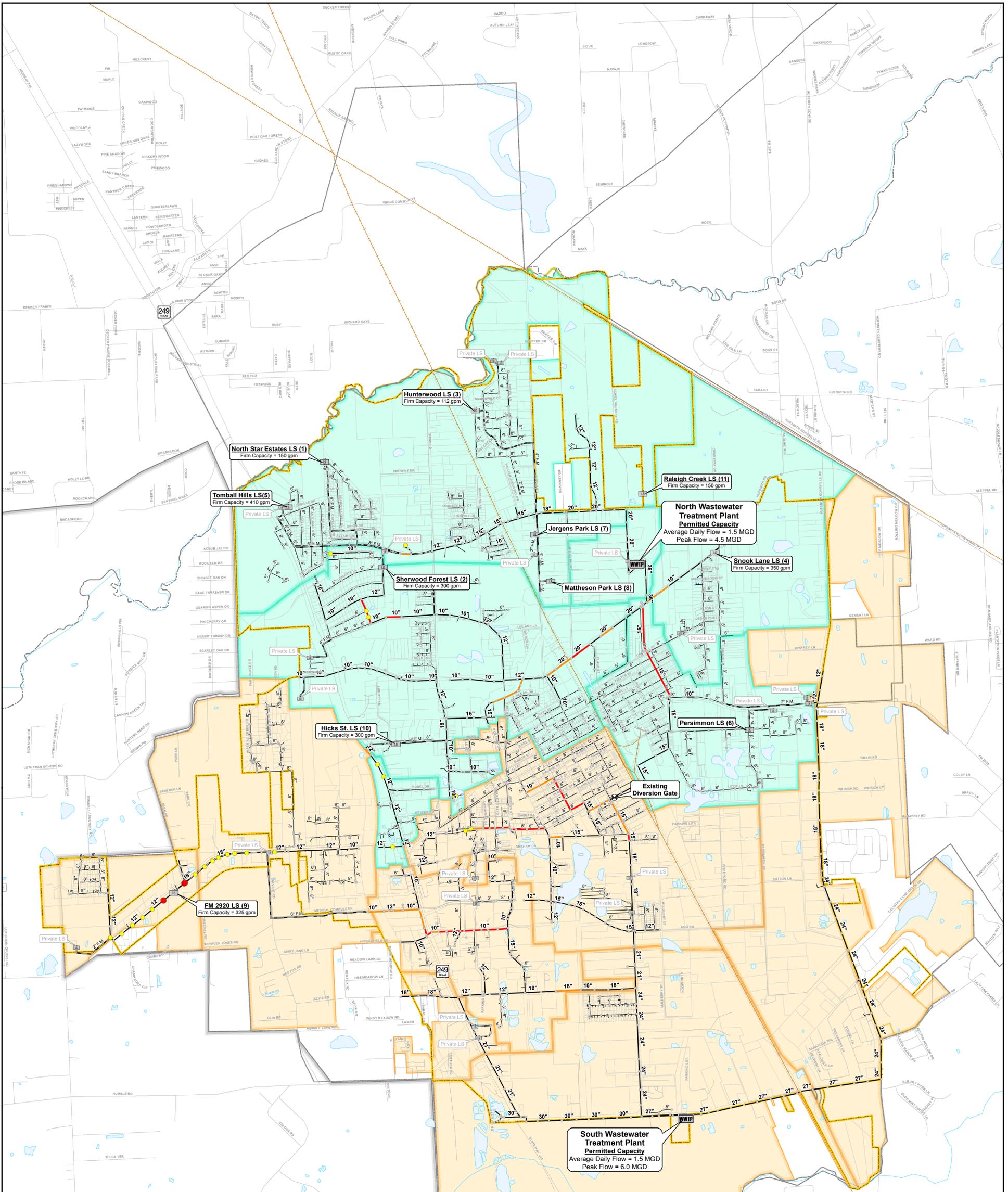
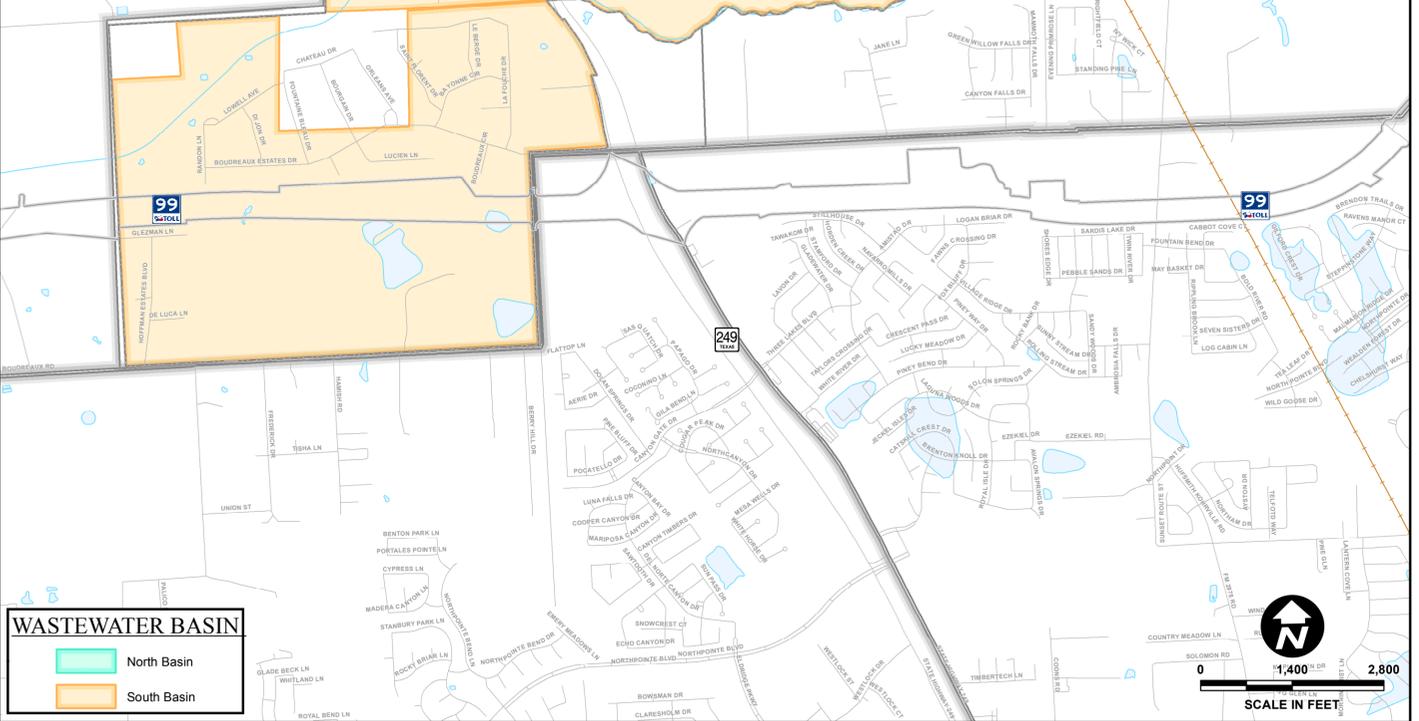


FIGURE 7-3
CITY OF TOMBALL
EXISTING SYSTEM ANALYSIS
PROJECTED 2042 FLOWS
LEGEND

- | | |
|------------------------------------|--------------------------------|
| Manhole Results | Wastewater Line Results |
| ● Manhole | — q/Q 0.80 - 0.99 |
| ● Surcharged within 3-ft of MH Rim | — q/Q Greater than 1 |
| ● Predicted Overflow | — Road |
| ⊗ Diversion Gate | — Railroad |
| ⊠ Lift Station | — Stream |
| ⊠ Private Lift Station | — Lake |
| ⊠ Wastewater Treatment Plant | — Parcel |
| — 8" and Smaller Wastewater Line | — Tomball City Limit |
| — 10" and Larger Wastewater Line | — Tomball ETJ |
| — 8" and Smaller Force Main | — Houston ETJ |
| — 10" and Larger Force Main | — County Boundary |



WASTEWATER BASIN

- North Basin
- South Basin

Created By: [Name] Date: [Date]
 Location: [Location]
 Date: [Date]

8.0 WASTEWATER TREATMENT PLANT ANALYSES

The wastewater flow projections developed in **Section 5.0** show that additional WWTP capacity is needed within the next 25 years to treat the identified wastewater flows within the study area. The City asked FNI to evaluate the financial impacts of consolidation to a single WWTP.

8.1 WWTP CONSOLIDATION ANALYSIS

FNI conducted a 25-year life cycle cost analysis to compare the financial impacts of operating two WWTPs vs. consolidating to a single WWTP. For this consolidation analysis, FNI considered the South WWTP site for the future single WWTP location due to the following factors:

1. Age and condition of the North WWTP
2. Availability of City-owned land at the South WWTP site
3. Available conveyance capacity of existing gravity lines in the South WWTP Service Area

Consolidation Alternatives

FNI evaluated the following alternatives for WWTP consolidation:

- **Alternative 1** – Both WWTPs remain in service and construct a 0.5 MGD expansion to the South WWTP beyond 10 years (Includes 10-Year rehabilitation projects at North WWTP)
- **Alternative 2a** – Decommission North WWTP and construct a 1.5 MGD expansion to the South WWTP beyond 10 years
- **Alternative 2b** – Decommission North WWTP and construct a 1.5 MGD expansion to the South WWTP within 5 years

The 25-year wastewater flow projections developed in **Section 5.0** show that an additional 0.5 MGD of treatment capacity is needed at the South WWTP *without* consolidation, and an additional 1.5 MGD of treatment capacity is needed at the South WWTP *with* consolidation. **Alternative 1** includes rehabilitation projects at the North WWTP identified by FNI in the City's *2016 Critical Needs Assessment of North and South WWTPs*. These improvements are included in the Wastewater CIP beyond 5 years (**CIP Project 10**). The difference between **Alternative 2a** and **Alternative 2b** is the timing of the WWTP consolidation, allowing for more time in the analysis to realize cost savings from the lower O&M cost of one WWTP.

Consolidation Analysis Parameters

The following parameters and costs were utilized for the life cycle cost evaluation alternatives:

- \$0.80/1000 Gallons O&M Cost for 1 WWTP
- \$1.40/1000 Gallons O&M Cost for 2 WWTPs
- Approx. \$6.9M for rehabilitation projects at the North WWTP (**CIP Project 10**)
- Approx. \$10.5M cost for diversion lift station, force main, and gravity line upgrades to convey peak flows from the north WWTP site to the South WWTP site.
- Approx. \$0.47M cost to decommission the North WWTP
- Approx. \$6.2M cost to construct a 0.5 MGD expansion to South WWTP (**CIP Project 16**)
- Approx. \$18.7M cost to construct a 1.5 MGD expansion to South WWTP
- 4% annual inflation rate
- 3% annual discount rate

Consolidation Analysis Results

The 25-year WWTP life cycle costs were computed for each alternative in 2017 dollars. The results of the consolidation analysis are summarized in **Table 8-1** and include construction, contingency, and engineering. The 25-year cost of operating the City's two existing WWTPs and expanding the South WWTP by 0.5 MGD is less than either of the consolidation alternatives. **Based on this analysis, FNI does not recommend consolidation of the City's WWTPs at this time.** FNI recommends that WWTP consolidation be re-evaluated during the City's next wastewater master planning effort.

Table 8-1: WWTP Consolidation 25-Year Life Cycle Cost Summary ⁽¹⁾⁽²⁾

WWTP Alternative ⁽³⁾	Phase	Category	Project	Capital Cost	Total 25-Year Life Cycle Cost (2017 \$)	No. of WWTPS
Alternative 1 Both WWTPs remain in service and 0.5 MGD Expansion to South WWTP (Includes 10-Year rehabilitation projects at North WWTP)	Beyond 10 Years	Treatment	0.5 MGD Expansion to South WWTP	\$6,240,000	\$47,349,000	2
		Conveyance	N/A	\$0		
		Rehabilitation	North WWTP Critical Needs Improvements – Priority 3	\$6,921,800		
	Alternative 1 Total Capital Cost			\$13,161,800		
Alternative 2a Decommission North WWTP and 1.5 MGD Expansion to South WWTP	Beyond 10 Years	Treatment	1.5 MGD Expansion to South WWTP	\$18,720,000	\$56,481,000	1
		Treatment	Decommission North WWTP	\$468,000		
		Conveyance	Diversion Infrastructure	\$10,554,400		
	Alternative 2a Total Capital Cost			\$29,742,400		
Alternative 2b Decommission North WWTP and 1.5 MGD Expansion to South WWTP	Within 5 Years	Treatment	1.5 MGD Expansion to South WWTP	\$18,720,000	\$50,421,000	1
		Treatment	Decommission North WWTP	\$468,000		
		Conveyance	Diversion Infrastructure	\$10,554,400		
	Alternative 2b Total Capital Cost			\$29,742,400		

(4) All costs include construction, contingency, and engineering

(5) Assumptions for O&M Costs: \$0.80/1,000 Gallons for 1 WWTP; \$1.40/1,000 Gallons for 2 WWTPS

(6) North and South WWTP Phase 1 Critical Needs Improvements currently planned for FY 2018 were not included in the 25-Year Life Cycle Cost Analyses

8.2 WWTP CAPACITY ANALYSES

The wastewater flow projections developed in **Section 5.0** show that additional WWTP capacity is needed within the next 25 years to treat the identified wastewater flows within the study area. FNI conducted capacity analyses at the North and South WWTPs to develop WWTP expansion recommendations. **Figure 8-1** and **Figure 8-2** show the total projected average day wastewater flows within each WWTP Service Area in each planning period.

75/90 Rule

Figure 8-1 and **Figure 8-2** each include three lines showing the **permitted average day flow (ADF) capacity of the WWTP**, **90% of the permitted ADF capacity**, and **75% of the permitted ADF capacity**. These are based on TCEQ §305.126, commonly referred to as the 75/90 rule, which requires a WWTP permit holder to begin planning for expansion of the treatment facility when the average day or average annual flow reaches 75% of the permitted capacity for three consecutive months. When the average day or average annual flow reaches 90% of the permitted capacity, the permit holder shall obtain necessary authorization from the Commission to commence construction of the necessary additional treatment facilities.

North WWTP Capacity Analysis

The flow projections on **Figure 8-1** indicate available capacity at the North WWTP to treat the projected 25-year flows in this study. No capacity expansion is needed based on this study's flow projections.

South WWTP Capacity Analysis

The flow projections on **Figure 8-2** indicate a lack of available capacity at the South WWTP to treat the projected 25-year flows in this study. FNI recommends that the City plan for a 0.5 MGD expansion at the South WWTP to occur beyond 2027. This WWTP expansion to a permitted capacity of 2.0 MGD is shown on **Figure 8-2**.

It should be noted that this 0.5 MGD expansion is based on the currently identified residential and commercial developments discussed in **Section 3.0** within the study area within the next 25 years. Future master planning efforts may identify a need for a larger WWTP expansion due to additional projected flows or WWTP consolidation.

Figure 8-1: North WWTP Projected Average Day Flows and Capacity

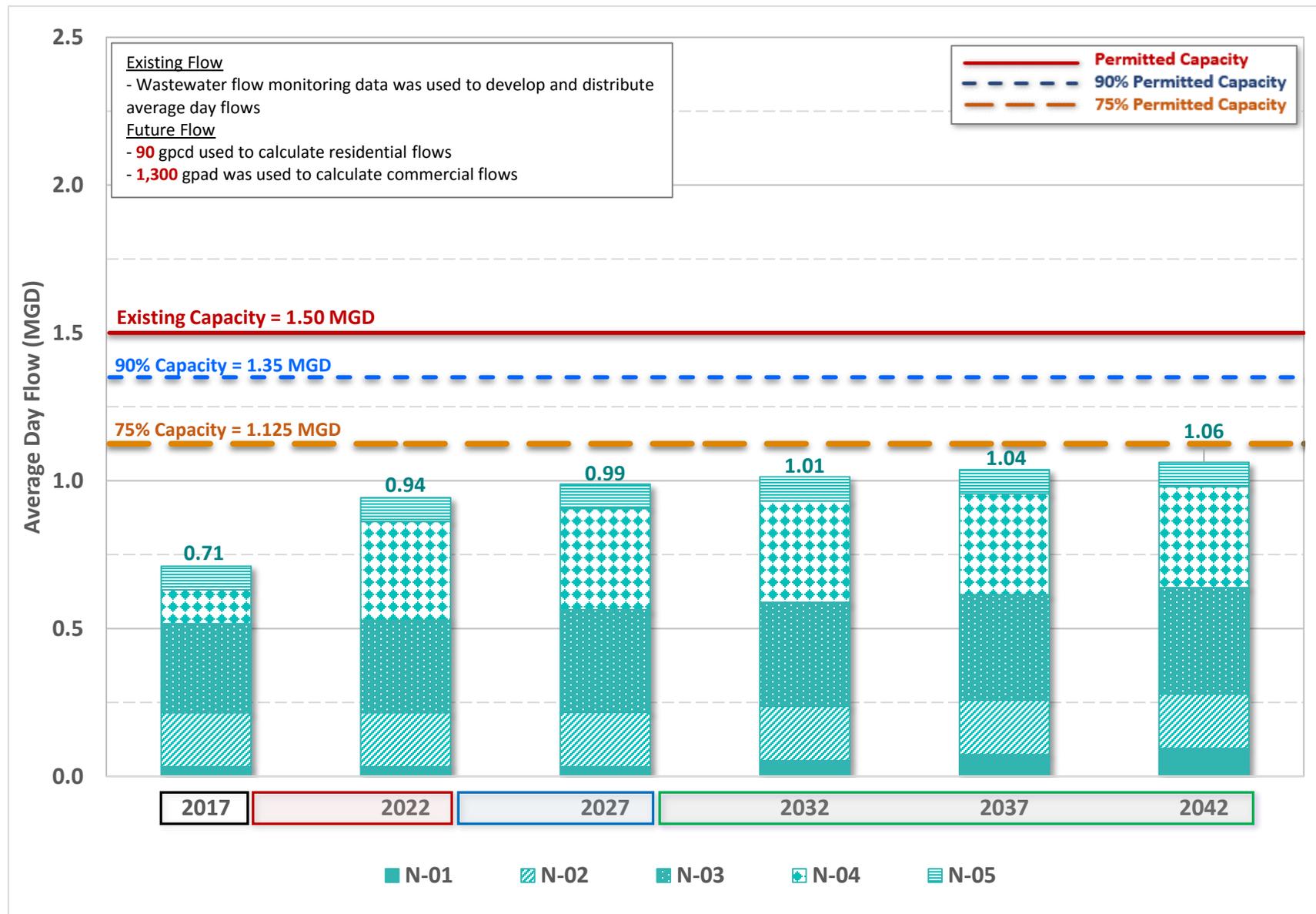
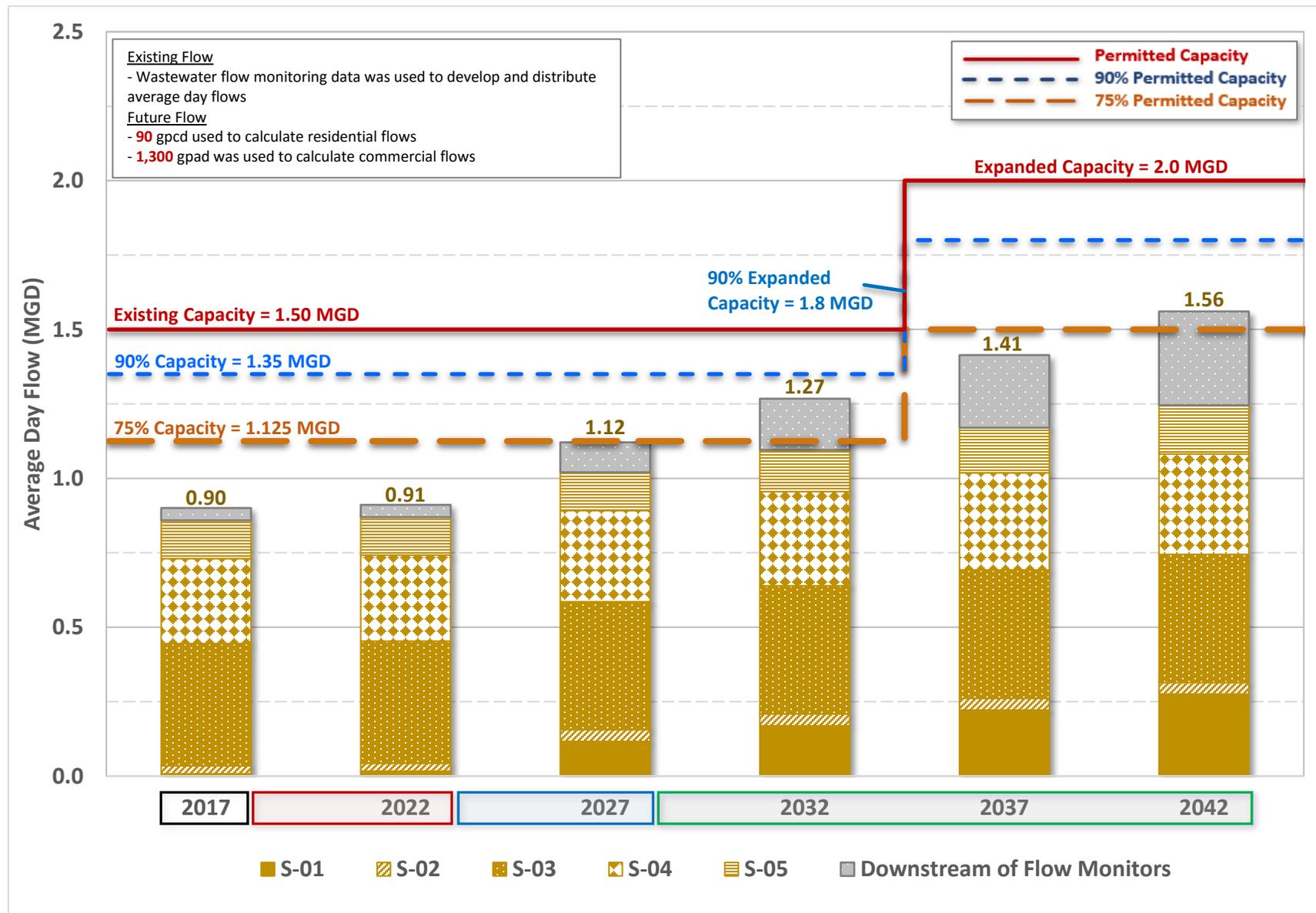


Figure 8-2: South WWTP Projected Average Day Flows and Capacity



9.0 INTEGRATED WASTEWATER CAPITAL IMPROVEMENTS PLAN

An integrated capital improvements plan was developed for the City's wastewater system. These projects address deficiencies in the existing collection system's ability to convey and treat wastewater flows and provide the required conveyance and treatment capacity to serve the projected residential and commercial growth through the 25-year planning period. The integrated wastewater CIP also includes sanitary sewer evaluation survey (SSES) projects to address the undesirable levels of I/I in the collection system, as well as WWTP improvements identified in the City's recent *2016 Critical Needs Assessment of North and South WWTPs* by FNI.

Wastewater projects currently under design by the City are not included in the CIP, and are shown in **orange** on **Figure 9-1**. All recommended infrastructure is sized to convey the projected 2042 peak wastewater flows (including I/I). It is recommended that these projects be constructed generally in the order listed; however, development or renewal patterns may make it necessary to construct some projects sooner than anticipated. Locations shown for new lines and other recommended improvements were generalized for hydraulic analyses. Specific alignments and sites will be determined as part of the design process.

Capital costs were calculated for all recommended improvements and do not include individual service connections or subdivision lines. The costs are provided as estimates based on previous similar engineering experience in 2017 dollars and include an allowance for engineering, surveying, and contingencies. Costs do not include easements or land acquisition. The pipeline and manhole unit costs are given in **Table 9-1**.

Table 9-2 summarizes the costs for each project by phase of the integrated wastewater CIP in 2017 dollars.

Additional Development

The infrastructure recommendations in this report incorporate the projected flows from the population and developments discussed in **Section 3.0**, within the wastewater study area (**Figure 3-1**).

It is recommended that existing and future wastewater system capacity be evaluated for any additional development beyond what is identified in this study.

Table 9-1: Wastewater Capital Improvements Plan Unit Costs

WWTP Expansion	Cost/Gallon
Standard Treatment	\$8
Pipelines	Cost/Diameter-inch/LF
Up to 8-ft installation depth	\$8
8 - 16-ft installation depth	\$9
16 – 20-ft installation depth	\$10
Manholes	Cost/Manhole
Standard 4-ft Diameter	
Up to 8-ft depth	\$7,500
Each additional foot of depth	\$250/foot
Standard 5-ft Diameter	
Up to 8-ft depth	\$10,000
Each additional foot of depth	\$500/foot
Standard 6-ft Diameter	
All depths	\$18,000
Contingency	%
All Projects	30%
Engineering & Survey	%
WWTPs and Lift Stations	20%
Gravity and Force Mains	15%

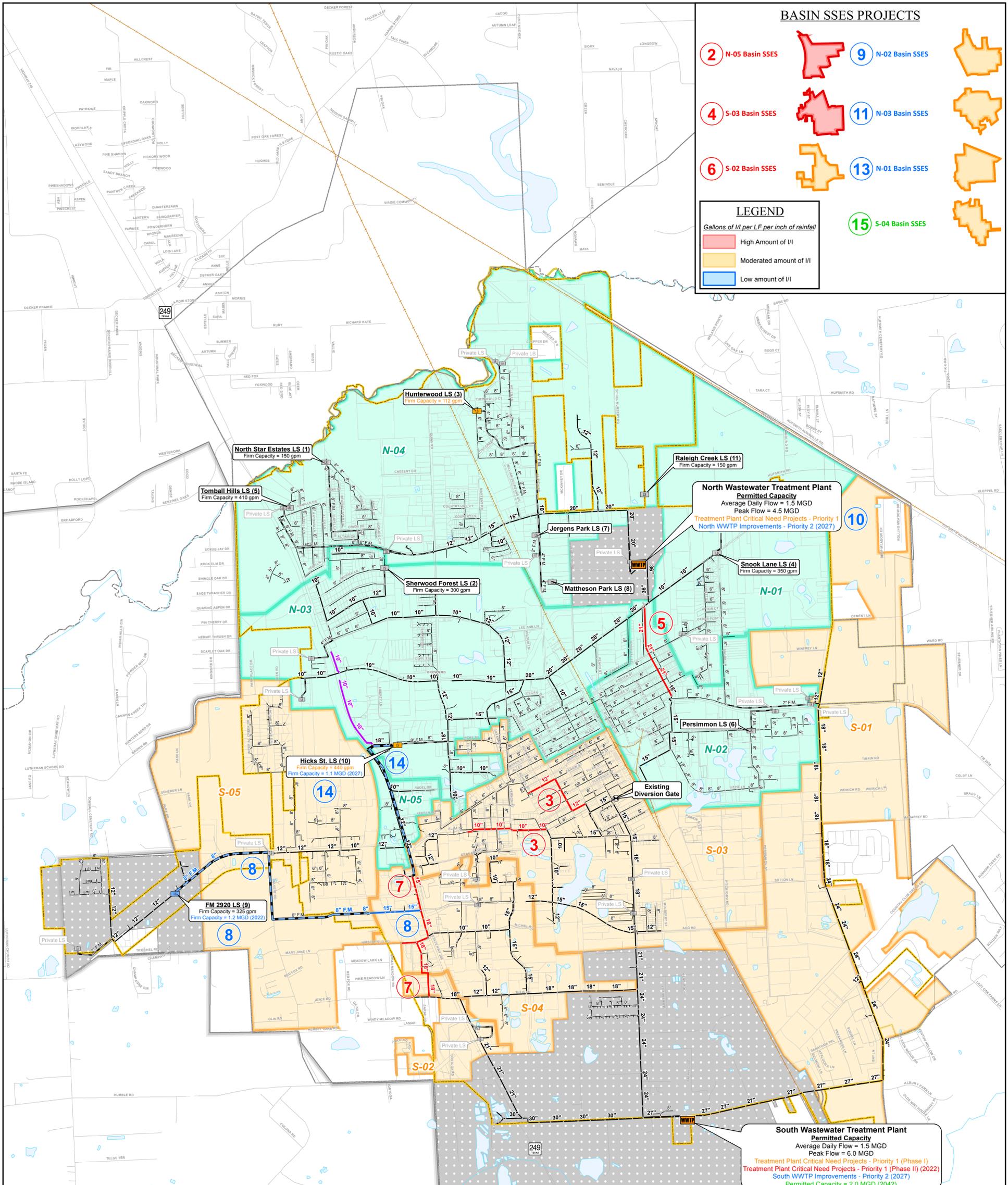
WWTPs Critical Needs Assessment

In 2016, the City retained FNI to conduct the *Critical Needs Assessment of North and South WWTPs*. FNI utilized a risk based condition assessment methodology that considered the condition and criticality of each treatment unit in evaluating the critical needs of the plants. The critical needs study recommended multiple projects at each WWTP. For this master plan study and the integrated wastewater CIP, the critical needs improvements have been separated into two priority levels. The City is currently implementing the Priority 1 projects at the North and South WWTPs (shown in **orange text** in the WWTP callouts). The Priority 2 WWTP improvement projects are included in the integrated wastewater CIP as **Project 10** and **Project 12**.

Table 9-2: Wastewater Capital Improvements Plan Summary

Phase	Project Number	Project Name	Cost (2017 \$)
by 2022	1	Treatment Plant Critical Needs Projects – Priority 1 (Phase II)	\$ 816,700 ⁽¹⁾
	2	SSES for Basin N-05 (Field Work and Rehabilitation)	\$ 278,100
	3	Replacement 10/12-inch Gravity Lines along Alma/James Streets	\$ 1,718,000
	4	SSES for Basin S-03 (Field Work and Rehabilitation)	\$ 3,573,900
	5	Replacement 21/24-inch North Willow Street Gravity Line	\$ 872,100
	6	SSES for Basin S-02 (Field Work and Rehabilitation)	\$ 521,200
	7	Replacement 15/18-inch Gravity Main along Tomball Pkwy (Hwy 249 B)	\$ 2,741,900
	Total 2017 - 2022		
by 2027	8	FM 2920 Lift Station Expansion, Replacement Force Main and Gravity Line Expansion	\$ 4,265,300
	9	SSES for Basin N-02 (Field Work and Rehabilitation)	\$ 1,464,600
	10	North WWTP Improvements - Priority 2	\$ 6,921,800
	11	SSES for Basin N-03 (Field Work and Rehabilitation)	\$ 2,389,400
	12	South WWTP Improvements - Priority 2	\$ 3,184,000
	13	SSES for Basin N-01 (Field Work and Rehabilitation)	\$ 556,900
	14	Hicks Lift Station Expansion and Replacement Force Main	\$ 1,558,200
	Total 2023 - 2027		
by 2027	15	SSES for Basin S-04 (Field Work and Rehabilitation)	\$ 1,463,700
	16	0.5 MGD Expansion of South WWTP	\$ 6,240,000
	Total 2028 - 2042		
Total 25-Year Wastewater CIP Cost			\$ 38,565,800

(1) Contractor markup for change order planned to be executed in 2018



BASIN SSES PROJECTS

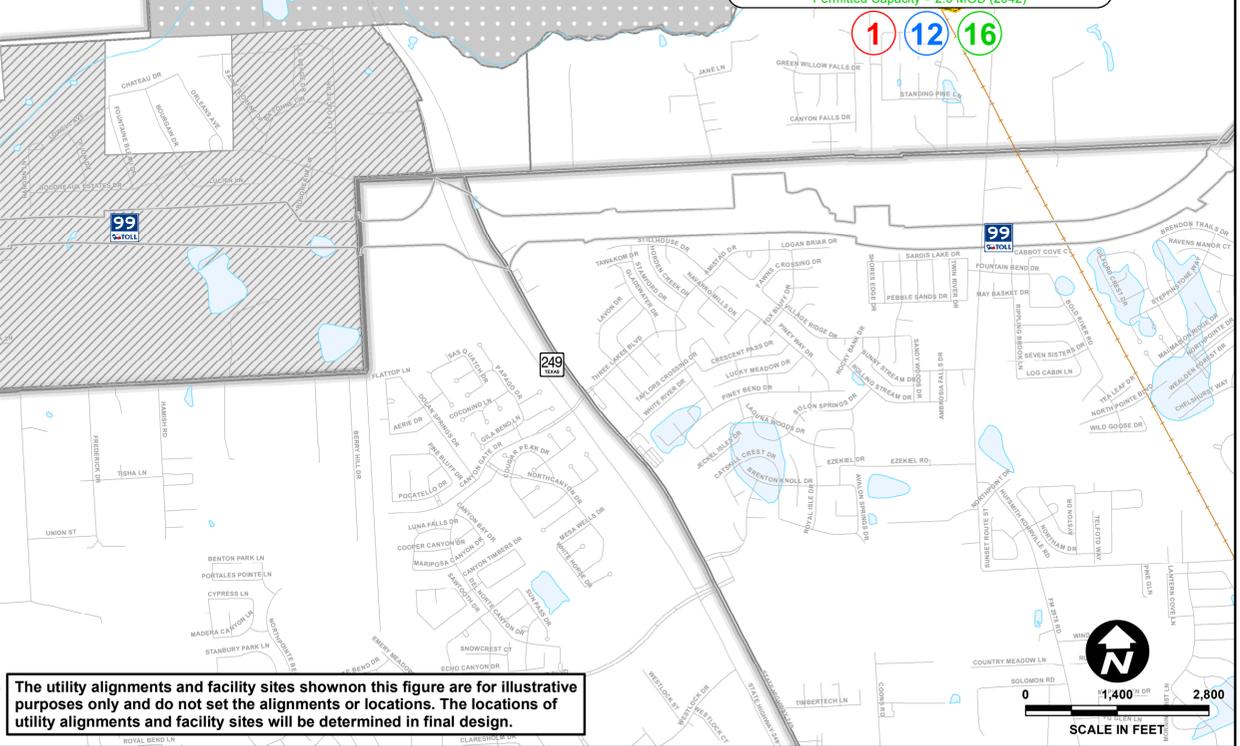
2 N-05 Basin SSES 9 N-02 Basin SSES
4 S-03 Basin SSES 11 N-03 Basin SSES
6 S-02 Basin SSES 13 N-01 Basin SSES
15 S-04 Basin SSES

LEGEND
 Gallons of I/I per LF per inch of rainfall
 High Amount of I/I
 Moderated amount of I/I
 Low amount of I/I

FIGURE 9-1
CITY OF TOMBALL
WASTEWATER MASTER PLAN
CAPITAL IMPROVEMENT RECOMMENDATIONS

LEGEND

Manhole	Proposed 2027 Force Main	County Boundary
Diversion Gate	8" and Smaller Force Main	North Basin
Proposed 2027 Lift Station	10" and Larger Force Main	South Basin
Under Rehabilitation Lift Station	Developer Project	Not Served Wastewater
Lift Station	Road	Downstream of Flow Monitor
Private Lift Station	Grand Parkway Right-Of-Way	CIP Project Numbers
Under Rehabilitation Wastewater Treatment Plant	Railroad	# 5-Year CIP (by 2022)
Proposed 2022 Wastewater Line	Stream	# 10-Year CIP (by 2027)
Proposed 202 Wastewater Line	Lake	# 25-Year CIP (by 2042)
8" and Smaller Wastewater Line	Parcel	
10" and Larger Wastewater Line	Tomball City Limit	
	Tomball ETJ	
	Houston ETJ	



The utility alignments and facility sites shown on this figure are for illustrative purposes only and do not set the alignments or locations. The locations of utility alignments and facility sites will be determined in final design.



9.1 FIVE-YEAR WASTEWATER COLLECTION AND TREATMENT PROJECTS (BY 2022)

Project 1 – Treatment Plant Critical Needs Projects – Priority 1 (Phase II)

Detailed Description: This project includes improvements to the South WWTP that were originally included in Critical Needs Improvements for North and South WWTPs Project (Tomball Project No. 2017-10002) but removed from the scope via change order. The improvements to the South WWTP included in this project are:

- New pump P-103 at influent lift station
- Variable Frequency Drives (VFDs) for the rotors in the oxidation ditch. SmartLite control panel for DO control. Actuators for the effluent weir gate. Expansion of MCC D&E building to house the VFDs.
- Two (2) new ultrasonic flow meter on RAS pump suction piping, one (1) new ultrasonic flow meter on RAS discharge header, one (1) new magmeters on WAS pipe.
- Expansion of Admin Building to include space for a new break room. New sidewalk and pavement. Rewiring of SCADA/PLC panel and provide new wiring diagrams to show current installation.
- New intake fan at the roof and replacement of exhaust fan in the chlorination building.

Purpose: A critical needs assessment of the North and South WWTPs was conducted in 2016 to identify the critical improvements required for both the WWTPs. Project No. 2017-10002 included all critical improvements identified for the North WWTP but only two of the critical improvements (main power feed switch gear replacement and non-potable water system upgrades) identified for the South WWTP since the Contractor's original bid price exceeded the budget allocated for the project for the fiscal year 2018. Several improvements to the South WWTP were removed from the scope via Change Order to the contract awarded for Project No. 2017-10002 to meet the budget allocated for the project for the fiscal year 2018. The purpose of this project is to add the improvements for the South WWTP removed for the original contract back in to Project No. 2017-10002 using the budget allocated for the fiscal year 2019.

Project 2 - SSES for Basin N-05 (Field Work and Rehabilitation)

Detailed Description: This project includes SSES field work to identify specific sources of I/I in the N-05 Basin. This project also includes an allowance for the design and construction of needed rehabilitation or repairs anticipated to be identified during the field work.

Purpose: The citywide flow monitoring conducted during this Master Plan study identified high levels of I/I in the N-05 Basin. It is anticipated that the rehabilitation and repairs from this project will reduce the amount of I/I sent to the North WWTP.

Project 3 - Replacement 10/12-inch Gravity Lines along Alma/James Streets

Detailed Description: This project includes the construction of a new 10-inch gravity line to replace the existing 8-inch line along Alma Street/James Street. This project also includes the construction of a new 12-inch gravity line to replace the existing 8-inch line along Magnolia Street.

Purpose: The hydraulic model indicates a lack of capacity in these lines to convey the existing peak wet weather flow. The recommended replacement gravity lines are sized to convey the existing and projected peak wet weather wastewater flows through 2042. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).

Project 4 - SSES for Basin S-03 (Field Work and Rehabilitation)

Detailed Description: This project includes SSES field work to identify specific sources of I/I in the S-03 Basin. This project also includes an allowance for the design and construction of needed rehabilitation or repairs anticipated to be identified during the field work.

Purpose: The citywide flow monitoring conducted during this Master Plan study identified high levels of I/I in the S-03 Basin. It is anticipated that the rehabilitation and repairs from this project will reduce the amount of I/I sent to the South WWTP.

Project 5 - Replacement 21/24-inch North Willow Street Gravity Line

Detailed Description: This project includes the construction of a new 21/24-inch gravity line to replace the existing 8-inch line along Magnolia Street.

Purpose: The hydraulic model indicates a lack of capacity in these lines to convey the existing peak wet weather flow. The recommended replacement gravity lines are sized to convey the existing and projected peak wet weather wastewater flows through 2042. The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53).

Project 6 - SSES for Basin S-02 (Field Work and Rehabilitation)

Detailed Description: This project includes SSES field work to identify specific sources of I/I in the S-02 Basin. This project also includes an allowance for the design and construction of needed rehabilitation or repairs anticipated to be identified during the field work.

Purpose: The citywide flow monitoring conducted during this Master Plan study identified high levels of I/I in the S-02 Basin. It is anticipated that the rehabilitation and repairs from this project will reduce the amount of I/I sent to the South WWTP.

Project 7 - Replacement 15/18-inch Gravity Main along Tomball Pkwy (Hwy 249 B)

Detailed Description: This project includes the construction of a new 15/18-inch gravity line to replace the existing 10/15-inch line along Tomball Pkwy (249B). The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53). This project also includes the construction of a new 18-inch gravity line parallel to Tomball Pkwy (connecting Hirschfield Road and Alice Road) and includes approximately 48,000 SF of easement acquisition.

Purpose: The hydraulic model indicates a lack of capacity in these lines to convey the existing peak wet weather flow. The recommended replacement gravity lines are sized to convey the existing and projected peak wet weather wastewater flows through 2042.

9.2 TEN-YEAR WASTEWATER COLLECTION AND TREATMENT PROJECTS (BY 2027)

Project 8 - FM 2920 Lift Station Expansion, Replacement Force Main and Gravity Line Expansion

Detailed Description: This project includes construction of a new 1.2 MGD Lift Station at the FM 2920 Lift Station and a 8-inch Force Main.

Purpose: The lift station wet well is sized for the projected 2042 peak flows from the Wastewater Service Area.

Project 9 - SSES for Basin N-02 (Field Work and Rehabilitation)

Detailed Description: This project includes SSES field work to identify specific sources of I/I in the N-02 Basin. This project also includes an allowance for the design and construction of needed rehabilitation or repairs anticipated to be identified during the field work.

Purpose: The citywide flow monitoring conducted during this Master Plan study identified high levels of I/I in the N-02 Basin. It is anticipated that the rehabilitation and repairs from this project will reduce the amount of I/I sent to the North WWTP.

Project 10 - North WWTP Improvements - Priority 2

Detailed Description: This project includes construction of new headworks with dual screens and grit removal system at North WWTP, and replacement of existing coarse bubble with fine bubble diffusers and new energy efficient blowers. This project also includes replacement of the existing non-functional centrifuge at the North WWTP and relocating it to a new building.

Note: Dependent upon timing, a future consolidation of the City's wastewater treatment plants at the South WWTP site would eliminate the need to construct the **Project 10** rehabilitation improvements.

Purpose:

- *North WWTP New Headworks with Dual Screens and Grit Removal System* - The current headworks consist on one screen with no redundancy and no room for expansion. The existing grit removal system is non-functional and hydraulically limited. A brand new headworks adjacent to the existing aeration basins is recommended. An efficient grit removal system will extend the life of the plant and is highly recommended if the aeration system at the plant is to be converted from coarse bubble to fine bubble for energy savings.
- *North WWTP Aeration Basin Improvements* - The aeration basins currently have coarse bubble diffusers. The blowers will reach the end of their useful life in the next 5 years or so and will require major rehab or replacement. Replacing the coarse with fine bubble diffusers and new high-speed turbo blowers will save energy costs.
- *North WWTP Centrifuge Replacement* - The existing centrifuge has been out of service for a long time now. The building that houses the centrifuge is in poor condition structurally. For long term improvements, a new building that can house a new dewatering system was recommended.

Project 11 - SSES for Basin N-03 (Field Work and Rehabilitation)

Detailed Description: This project includes SSES field work to identify specific sources of I/I in the N-03 Basin. This project also includes an allowance for the design and construction of needed rehabilitation or repairs anticipated to be identified during the field work.

Purpose: The citywide flow monitoring conducted during this Master Plan study identified high levels of I/I in the N-03 Basin. It is anticipated that the rehabilitation and repairs from this project will reduce the amount of I/I sent to the North WWTP.

Project 12 - South WWTP Improvements - Priority 2

Detailed Description: This project includes the addition of a second mechanical screen and a new grit classifier at the South WWTP. This project also includes a second sludge dewatering unit for redundancy.

Purpose:

- *South WWTP Mechanical Screen and Grit Classifier* - The existing headworks has only one mechanical screen. A second screen is recommended for redundancy. A new grit classifier is recommended to wash and dewater the grit removed.
- *South WWTP Sludge Dewatering Unit* - Currently, there is only one centrifuge unit at the plant to dewater sludge. When the centrifuge is out of service for extended periods of time, the City rents a belt filter press mounted in a trailer from a third party to dewater sludge. This project is to install a second sludge dewatering unit at the plant for redundancy to the existing centrifuge. It will require expansion of the existing centrifuge building or a new building to house the second dewatering unit.

Project 13 - SSES for Basin N-01 (Field Work and Rehabilitation)

Detailed Description: This project includes SSES field work to identify specific sources of I/I in the N-01 Basin. This project also includes an allowance for the design and construction of needed rehabilitation or repairs anticipated to be identified during the field work.

Purpose: The citywide flow monitoring conducted during this Master Plan study identified high levels of I/I in the N-01 Basin. It is anticipated that the rehabilitation and repairs from this project will reduce the amount of I/I sent to the North WWTP.

Project 14 - Hicks Lift Station Expansion and Replacement Force Main

Detailed Description: This project includes a new 1.1 MGD (firm capacity) Lift Station at Hicks Street. The project also includes construction of a 8-inch Force Main from Hicks Street to Park Drive.

Purpose: The lift station wet well and the force main are sized for the projected 2042 peak flows from the Wastewater Service Area.

9.3 TWENTY FIVE-YEAR WASTEWATER COLLECTION AND TREATMENT PROJECTS (BY 2042)

Project 15 - SSES for Basin S-04 (Field Work and Rehabilitation)

Detailed Description: This project includes SSES field work to identify specific sources of I/I in the S-04 Basin. This project also includes an allowance for the design and construction of needed rehabilitation or repairs anticipated to be identified during the field work.

Purpose: The citywide flow monitoring conducted during this Master Plan study identified moderate levels of I/I in the S-04 Basin. It is anticipated that the rehabilitation and repairs from this project will reduce the amount of I/I sent to the South WWTP.

Project 16 - 0.5 MGD Expansion of South WWTP

Detailed Description: This project includes the expansion of the South WWTP from 1.5 MGD to 2.0 MGD permitted ADF capacity.

Purpose: The wastewater flow projections show a lack of available capacity at the South WWTP to treat the projected 25-year flows in this study. This 0.5 MGD expansion of the South WWTP will provide the available capacity to treat the projected wastewater flows. It should be noted that this 0.5 MGD expansion is based on the projected flows within the next 25 years. Future master planning efforts may identify a need for a larger expansion due to additional projected flows or WWTP consolidation.

APPENDIX A
Wastewater System CIP -
Planning Level Opinion of Probable Construction Cost (OPCC) Sheets

Wastewater Master Plan CIP - Opinion of Probable Construction Cost

10/12/17

CIP Project Number:

1

Phase: **by 2022**

Project Name: Treatment Plant Critical Needs Projects - Priority 1 (Phase II)

Detailed Description:

This project includes improvements to the South WWTP that were originally included in Critical Needs Improvements for North and South WWTPs Project (Tomball Project No. 2017-10002) but removed from the scope via change order. The improvements to the South WWTP included in this project are:

- New pump P-103 at influent lift station
- Variable Frequency Drives (VFDs) for the rotors in the oxidation ditch. SmartLite control panel for DO control. Actuators for the effluent weir gate. Expansion of MCC D&E building to house the VFDs.
- Two (2) new ultrasonic flow meter on RAS pump suction piping, one (1) new ultrasonic flow meter on RAS discharge header, one (1) new magmeters on WAS pipe.
- Expansion of Admin Building to include space for a new break room. New sidewalk and pavement. Rewiring of SCADA/PLC panel and provide new wiring diagrams to show current installation.
- New intake fan at the roof and replacement of exhaust fan in the chlorination building.

Purpose:

A critical needs assessment of the North and South WWTPs was conducted in 2016 to identify the critical improvements required for both the WWTPs. Project No. 2017-10002 included all critical improvements identified for the North WWTP but only two of the critical improvements (main power feed switch gear replacement and non-potable water system upgrades) identified for the South WWTP since the Contractor's original bid price exceeded the budget allocated for the project for the fiscal year 2018. Several improvements to the South WWTP were removed from the scope via Change Order to the contract awarded for Project No. 2017-10002 to meet the budget allocated for the project for the fiscal year 2018. The purpose of this project is to add the improvements for the South WWTP removed for the original contract back in to Project No. 2017-10002 using the budget allocated for the fiscal year 2019.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE ⁽¹⁾	TOTAL
1	WWTP Critical Needs - (Priority 1) Phase II	1	EA	\$ 756,143	\$ 756,143
				SUBTOTAL:	\$ 756,200
				CONTRACTOR MARKUP ⁽²⁾	\$ 60,500
				SUBTOTAL:	\$ 816,700
Estimated Project Total:					\$ 816,700

(1) 2017 dollars

(2) Contractor markup for change order planned to be executed in 2018

Wastewater Master Plan CIP - Opinion of Probable Construction Cost

10/12/17

CIP Project Number:

7

Phase: **by 2022**

Project Name: Replacement 15/18-inch Gravity Main along Tomball Pkwy (Hwy 249 B)

Project Description:

This project includes the construction of a new 15/18-inch gravity line to replace the existing 10/15-inch line along Tomball Pkwy (249B). The additional capacity provided by this replacement line will help the City maintain regulatory compliance regarding the prevention of surcharging and sanitary sewer overflows in a gravity sewer system (TCEQ §217.53). This project also includes the construction of a new 18-inch gravity line parallel to Tomball Pkwy (connecting Hirschfield Road and Alice Road) and includes approximately 48,000 SF of easement acquisition.

Project Drivers:

The hydraulic model indicates a lack of capacity in these lines to convey the existing peak wet weather flow. The recommended replacement gravity lines are sized to convey the existing and projected peak wet weather wastewater flows through 2042.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	18" Pipe 8- 16 feet deep	2,000	LF	\$ 162	\$ 324,000
2	18" Pipe > 16 feet deep	1,300	LF	\$ 180	\$ 234,000
3	15" Pipe 8- 16 feet deep	1,200	LF	\$ 135	\$ 162,000
4	10" Pipe < 8 feet deep	500	LF	\$ 80	\$ 40,000
5	60" Diameter Manhole (12' Depth)	17	EA	\$ 12,000	\$ 204,000
6	Pavement Repair	3,500	LF	\$ 75	\$ 262,500
7	34" Boring and Casing	150	LF	\$ 850	\$ 127,500
8	Easement Acquisition	48,000	SF	\$ 10	\$ 480,000
SUBTOTAL:					\$ 1,834,000
CONTINGENCY				30%	\$ 550,200
SUBTOTAL:					\$ 2,384,200
ENG/SURVEY				15%	\$ 357,700
SUBTOTAL:					\$ 2,741,900
Estimated Project Total:					\$ 2,741,900

City of Tomball



Wastewater Master Plan CIP - Opinion of Probable Construction Cost

10/12/17

CIP Project Number:

8

Phase: by 2027

Project Name:

FM 2920 Lift Station Expansion, Replacement Force Main and Gravity Line Expansion

Detailed Description:

This project includes construction of a new 1.2 MGD Lift Station at the FM 2920 Lift Station and a 8-inch Force Main.

Purpose:

The lift station wet well is sized for the projected 2042 peak flows from the Wastewater Service Area.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	FM 2920 - Wet Well Replacement	1	EA	\$ 271,200	\$ 271,200
2	FM 2920 - Pumps	1	EA	\$ 86,400	\$ 86,400
3	FM 2920 - Electrical	1	EA	\$ 144,000	\$ 144,000
4	FM 2920- Generator	1	EA	\$ 86,400	\$ 86,400
5	FM 2920 - Piping and Valves	1	EA	\$ 69,600	\$ 69,600
6	8" Force Main < 8 feet deep	8,000	LF	\$ 64	\$ 512,000
7	15" Pipe 8- 16 feet deep	5,200	LF	\$ 135	\$ 702,000
8	Pavement Repair	700	LF	\$ 75	\$ 52,500
9	30" Boring and Casing	800	LF	\$ 750	\$ 600,000
10	60" Diameter Manhole (9' Depth)	20	EA	\$ 10,500	\$ 210,000
SUBTOTAL:					\$ 2,734,100
CONTINGENCY				30%	\$ 820,300
SUBTOTAL:					\$ 3,554,400
ENG/SURVEY				20%	\$ 710,900
SUBTOTAL:					\$ 4,265,300
Estimated Project Total:					\$ 4,265,300

CIP Project Number:

10

Phase: **by 2027**

Project Name: North WWTP Improvements - Priority 2

Detailed Description:

This project includes construction of new headworks with dual screens and grit removal system at North WWTP, and replacement of existing coarse bubble with fine bubble diffusers and new energy efficient blowers. This project also includes replacement of the existing non-functional centrifuge at the North WWTP and relocating it to a new building.

Purpose:

North WWTP New Headworks with Dual Screens and Grit Removal System

The current headworks consist on one screen with no redundancy and no room for expansion. The existing grit removal system is non-functional and hydraulically limited. A brand new headworks adjacent to the existing aeration basins is recommended. An efficient grit removal system will extend the life of the plant and is highly recommended if the aeration system at the plant is to be converted from coarse bubble to fine bubble for energy savings.

North WWTP Aeration Basin Improvements

The aeration basins currently have coarse bubble diffusers. The blowers will reach the end of their useful life in the next 5 years or so and will require major rehab or replacement. Replacing the coarse with fine bubble diffusers and new high speed turbo blowers will save energy costs.

North WWTP Centrifuge Replacement

The existing centrifuge has been out of service for a long time now. The building that houses the centrifuge is in poor condition structurally. For long term improvements, a new building that can house a new dewatering system was recommended.

Opinion of Probable Construction Cost

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL
1	New headworks with dual screen and grit removal system	1	EA	\$ 2,041,000	\$ 2,041,000
2	Aeration Basin diffuser and blower improvements	1	EA	\$ 1,065,000	\$ 1,065,000
3	Centrifuge replacement and relocation in new building	1	EA	\$ 1,331,000	\$ 1,331,000
				SUBTOTAL:	\$ 4,437,000
				CONTINGENCY	30%
					\$ 1,331,100
				SUBTOTAL:	\$ 5,768,100
				ENG/SURVEY	20%
					\$ 1,153,700
				SUBTOTAL:	\$ 6,921,800
Estimated Project Total:					\$ 6,921,800

APPENDIX B
Lift Station Inventory

Lift Station Name (#) Address	Wet Well					Force Main		Pump							
	Diameter (ft)	Ground Elevation (MSL)	Bottom of Wet Well (MSL)	Influent Pipe Diameter (in)	Influent Pipe Flowline(s) (MSL)	Force Main Diameter (in)	Force Main Length (ft)	Number of Pumps	Model/ Manufacturer/ Serial	Firm Capacity (gpm)	Horse Power	TDH (ft)	1st Pump ON level (MSL)	2nd Pump ON level (MSL)	Pump OFF level (MSL)
North Star Estates (1) 31530 Capella Circle	8 x 8	164.67	144.67	8	158.34	8	5480	2	Flygt 3140.180-0628	150	15	-	153	155	151
Sherwood Forest (2) 30203 Wickford Dr.	4	210.32	191.65	6 / 12 / 10	195.61 (N) / 203.32 (S)	6	480	2	Flygt 3102 Hydromatic Pump Serial 16503 Model 40 MMP Imp Dia: 7.5"	300	5	-	203.5	204.5	203
Hunterwood (3) 13406 Julia Lane	6	181.87	164	8	168.5	4	4610	2	Flygt NP 3127 HT-3 - Adaptive 489	112	7.5	63	167	167.5	165
Snook Lane (4) 1035 E. Hufsmith Rd.	5	172	152.25	8	168.17 (N) / 167.17 (S)	4	580	2	Flygt 3085.120-830362	115	2	-	174	194	141
Tomball Hills (5) 28106 Chris Lane	8	168.5	141.5	15	145.3	6	4670	2	Flygt Model Np 3171.185 Submersible	410	35	140	144.63	145.3	143
Persimmon (6) 303 S. Persimmon	4	179.2	158.8	6 / 8 / 8	6" (NE) 167.25 8" (S) 163.16 8" (E) 163.15	4	120	2	NP3085 Flygt 3085.181-4345	-	3	-	164	170	161.25
Jergens Park (7) Ulrich Rd. at Jergens Park	3	-	-	6	-	2	660	2	Myers 7200 - 0175 H4HN	-	2	-	-	-	-
Matheson Park (8) Ulrich Rd. at Matheson Park	4	-	-	8	-	4	2550	2	Myers 4V50M4-21	-	5	-	-	-	-
FM 2920 (9) 15303 FM 2920	6	173.93	153.93	12	158.305-W / 159.013-E	8	7950	2	Flygt 3140.090-6068	325	15	77	194	205	179
Hicks St. (10) 1519 Hicks St.	8	181	157.1	8	163.88	8	1470	2	Flygt NP3127 LT 3-422	440	7.5	36	161.1	162.1	158.1
Raleigh Creek (11) 30615 Raleigh Creek Dr.	8	170	138	12	142	6	185	2	EBARA Submersible Pumps Model 100DLMFU63.7	350	5	30	145	155	142

Data Sources	
As-Built Data	GIS Data
Information From City	Estimate from Pump Vendor Curves
Contour Data	
Field Survey Data	Model Assumption

APPENDIX C
Sewer System Performance Report (by ADS) Incl. Flow Monitor Site Reports

Sewer System Performance Report

Tomball, Texas

PREPARED FOR

David Esquivel, P.E.

501 James St.
Tomball, TX 77375

SUBMITTED

March 2017

**ADS ENVIRONMENTAL
SERVICES®**





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Appendix A – Flow Monitor Site Installation Details

Appendix B – Flow Monitor Equipment Specifications

Appendix C – Flow Monitor Data

CD-ROM with electronic copy of report and associated data accompanies this report





Introduction

ADS Environmental Services (ADS) was retained by The City of Tomball, Texas to gather and evaluate flow monitor and rainfall data within selected portions of the existing sanitary sewer system located in Tomball. The scope of this study is to characterize dry weather and wet weather flow conditions at key locations within the sewer system, evaluate key performance indicators, and rank the relative severity of observed rainfall-dependent inflow and infiltration (RDII) to assist the Engineer to direct subsequent planning, condition assessment, and rehabilitation activities.

Methodology

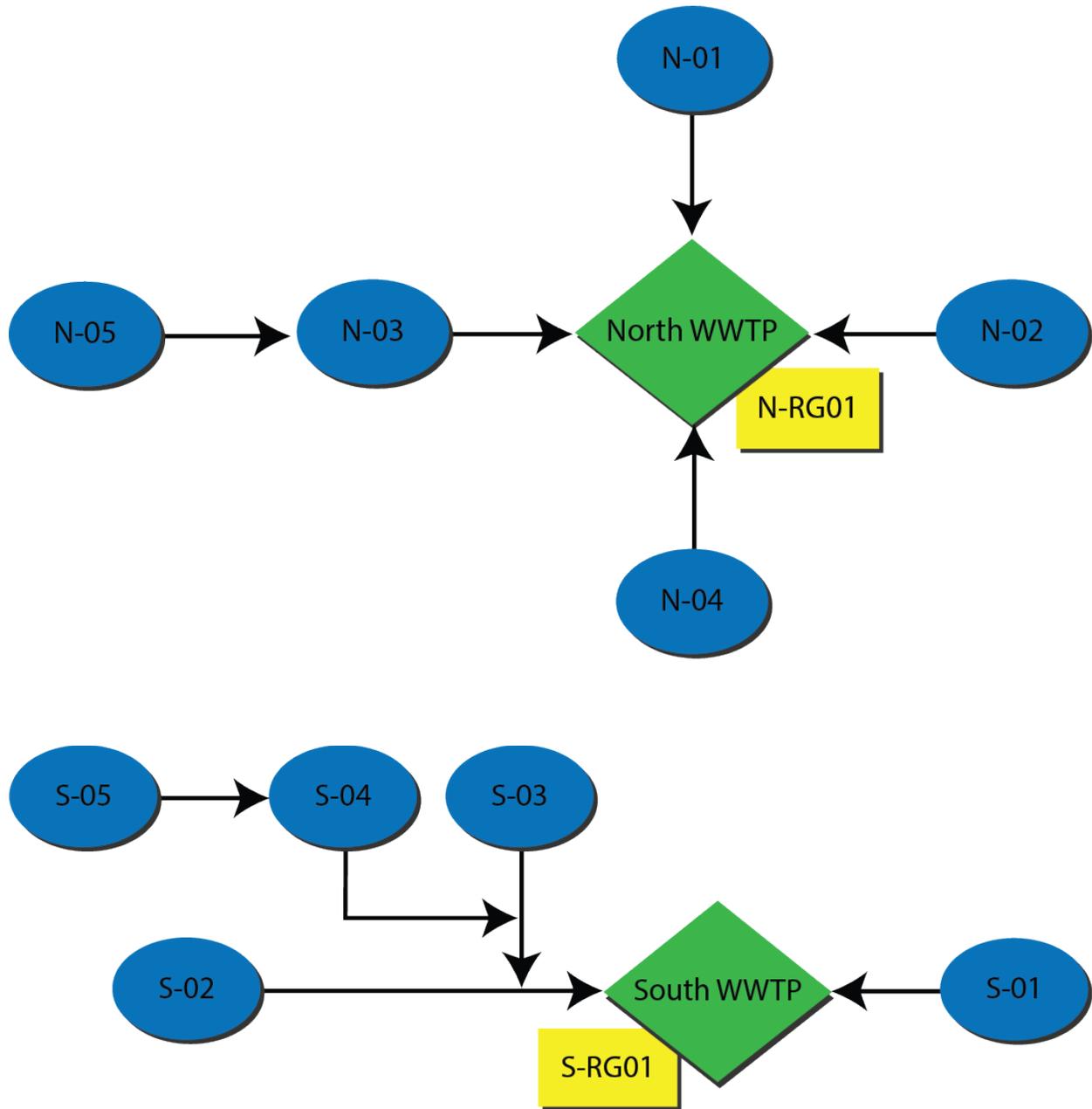
Dry weather and wet weather performance data were obtained by installing sewer flow monitors to observe and document existing flow conditions. A total of two sewer basins were evaluated using 10 temporary flow monitors two temporary rain gauges. ADS maintained the temporary flow monitors during the study. Descriptions of the temporary flow monitor locations, equipment, study period, and data format are detailed in the following sections.

Flow Monitor Locations

Preliminary flow monitor and rain gauge locations were selected by the Engineer, and final locations were determined by ADS based on observed flow conditions, site access, and site safety considerations. A general flow monitor schematic developed by ADS displays the relationship between each flow monitors and is shown in Figure 1. Descriptions of each sewer basin and its associated flow monitor are provided in Table 1. Diameters reported in the table are based upon field measurements by ADS personnel.



Figure 1: Flow Monitor Schematic



**Table 1: Flow Monitor Basin Descriptions**

Monitor	Diameter (inches)	Basin Size (LF)
N-01	9.75	13,814
N-02	18.0	45,634
N-03	27.25	77,698
N-04	20.25	69,310
N-05	12.0	8,121
S-01	27.25	15,856
S-02	20.5	5,666
S-03	20.5	83,292
S-04	17.5	33,182
S-05	17.0	29,149

Site installation reports with more detailed location information for each flow monitor and rain gauge are provided in Appendix A.

Flow Monitor Equipment

Sewer flow monitoring was performed using FlowShark Triton flow monitors manufactured, installed, and maintained by ADS. Each flow monitor is mounted near the top of a manhole and is connected to flow depth and velocity sensors positioned in an incoming sewer. Detailed specifications of the flow monitor equipment used for this project are provided in Appendix B.

Flow Monitor Study Period

Flow monitors and rain gauges were installed 11/08/2016 through 11/28/2016. The study period was then commissioned on 11/29/2016 and continued through 2/5/2017, a total duration of 69 days.

Flow Monitor Data Format

Flow depth (d), flow velocity (v), and flow rate (Q) data from each sewer flow monitor are plotted on a variety of hydrographs and scattergraphs provided in Appendix C. Hydrographs display flow rate data vs. time for the duration of the observation period, along with associated rainfall data. Scattergraphs display flow depth vs. flow velocity data for each location. Electronic copies of the data are provided in Microsoft Excel format.



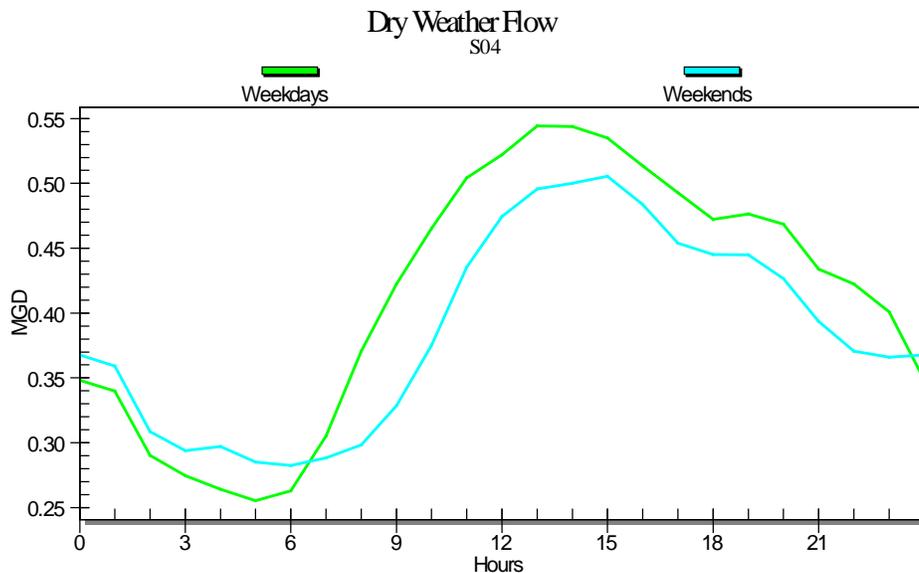
Results

Flow monitor data provide insight into sewer performance – revealing important information about how the existing sewer system accommodates observed flow rates. The following sections evaluate flow monitor data observed during both dry weather and wet weather periods using a variety of key performance indicators (KPIs).

Flow Rates and Peaking Factors

Dry weather flow conditions are characterized by evaluating flow monitor data observed during normal conditions, excluding wet weather events and the periods associated with the recovery from these events. The average dry day pattern is identified as a diurnal pattern and results from the collective sewer use of residential, commercial, institutional, and industrial users located upstream from a given flow monitor. Land use within a particular area affects the shape of the diurnal pattern. An example of a representative diurnal pattern observed during the study period is shown in Figure 2.

Figure 2: Dry Weather Hydrograph

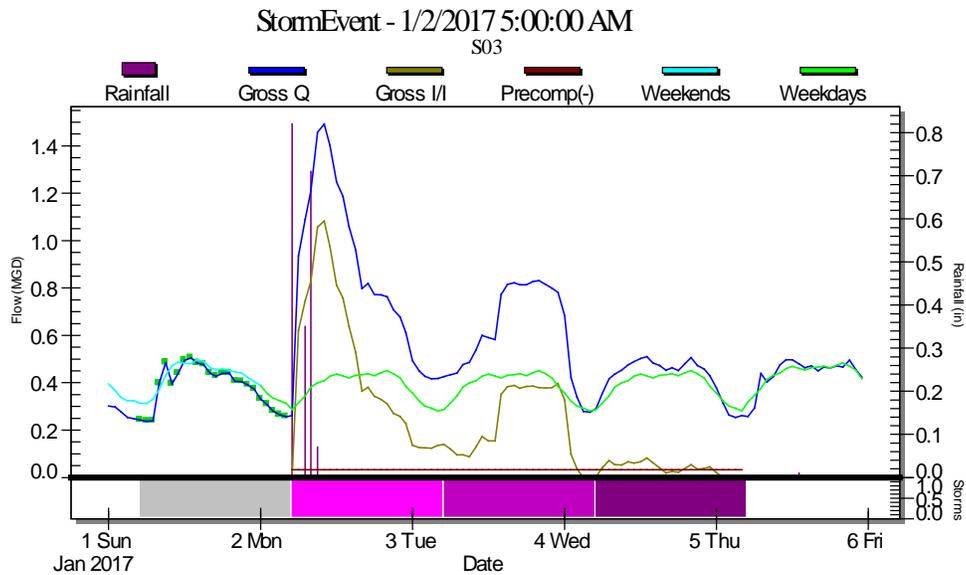


Wet weather flow conditions are characterized by evaluating flow monitor data observed during significant storm events that occurred during the study period. A wet weather storm decomposition hydrograph is provided in Figure 3 and shows the observed flow rate during a storm event compared to the average dry day diurnal pattern. The difference between the two is the rainfall dependent inflow and infiltration (RDII) measured by the flow monitor. The storm event is depicted by the purple bands, and a precompensation period prior to the storm is



depicted by the light gray band. Precompensation is used, when needed, to adjust the average dry day diurnal pattern to more closely match observed conditions prior to each storm event for proper RDII analysis.

Figure 3: Wet Weather Storm Decomposition Hydrograph



The minimum, average, and maximum dry weather flow rates ($Q_{\min-D}$, $Q_{\text{avg-D}}$, and $Q_{\max-D}$) are determined from the dry weather diurnal pattern for each flow monitor location and are provided in Table 2, along with the resulting gross dry weather peaking factor (PF_D). The maximum wet weather flow rate ($Q_{\max-W}$) determined for each flow monitor location is also provided, along with the resulting gross wet weather peaking factor (PF_W).



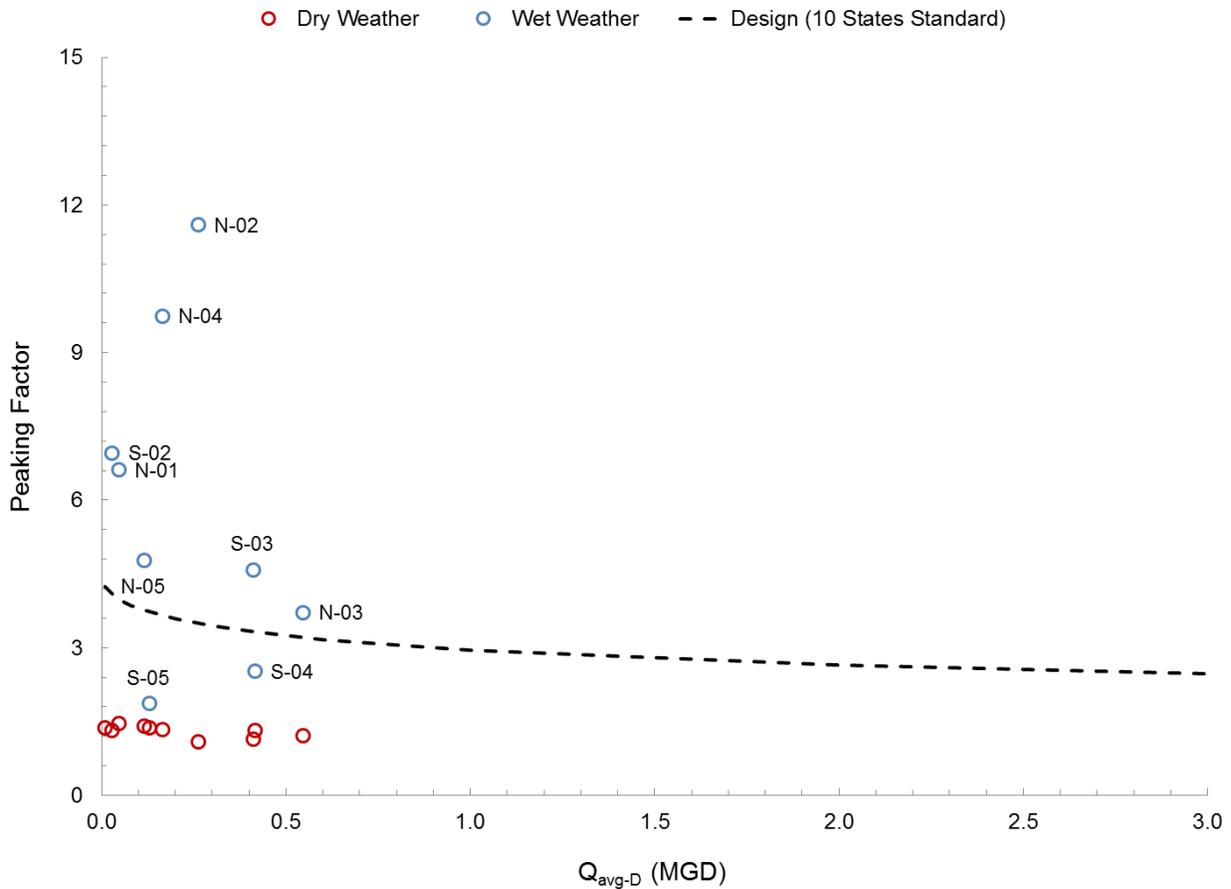
**Table 2: Gross Dry and Wet Weather Flow Rates and Peaking Factors**

Monitor	$Q_{\min-D}$ (MGD)	$Q_{\text{avg-D}}$ (MGD)	$Q_{\max-D}$ (MGD)	$Q_{\max-W}$ (MGD)	Peaking Factor PF_D	Peaking Factor PF_W
N-01	0.018	0.045	0.066	0.298	1.47	6.62
N-02	0.219	0.262	0.288	3.039	1.10	11.60
N-03	0.317	0.545	0.663	2.033	1.22	3.73
N-04	0.059	0.163	0.220	1.590	1.35	9.75
N-05	0.055	0.114	0.162	0.545	1.42	4.78
S-01	0.006	0.008	0.011	0.451	1.38	56.38
S-02	0.017	0.027	0.036	0.188	1.33	6.96
S-03	0.305	0.410	0.475	1.884	1.16	4.60
S-04	0.256	0.414	0.547	1.047	1.32	2.53
S-05	0.062	0.128	0.178	0.240	1.39	1.88

Peaking factors are commonly used to estimate maximum flow rates based on average flow rate estimates and play a key role in sewer design. Peaking factors are inversely proportional to the population served and generally decrease as the average dry weather flow rate increases. Dry weather and wet weather peaking factors observed during the study period are compared with corresponding design guidance from the American Society of Civil Engineers (ASCE) and the Water Environment Federation (WEF), and the results are shown in Figure 4.



Figure 4: Gross Peaking Factors Compared to Design Guidance



Observed dry weather peaking factors fall within design guidelines, but most of the wet weather peaking factors observed were above these values and result from RDII originating upstream from these flow monitor locations. The largest gross peaking factor observed during the study period, which is not shown on the plot, was a value of 56.38 at Site S-01. The large peaking factor is partially attributable to a very low average dry day flow at this site. Wet weather peaking factors at the remaining flow monitor locations ranged from 1.88 to 11.60.

Depth-to-Diameter Ratios

Once dry weather and wet weather flow rates are characterized, the hydraulic conditions under which they occur are evaluated. The maximum flow depth observed during dry weather (d_{max-D}) and wet weather (d_{max-W}) and their corresponding flow depth-to-diameter (d/D) ratios observed during the study period are provided in Table 3. The D values shown in the table represent field measurements for each pipe. The maximum dry weather flow depth is the flow depth associated with the maximum dry weather flow rate and is the maximum flow depth that is





consistently observed each day during normal dry weather conditions. The maximum wet weather flow depth may or may not be directly associated with the maximum wet weather flow rate, depending on the hydraulic conditions observed at a given flow monitor location.

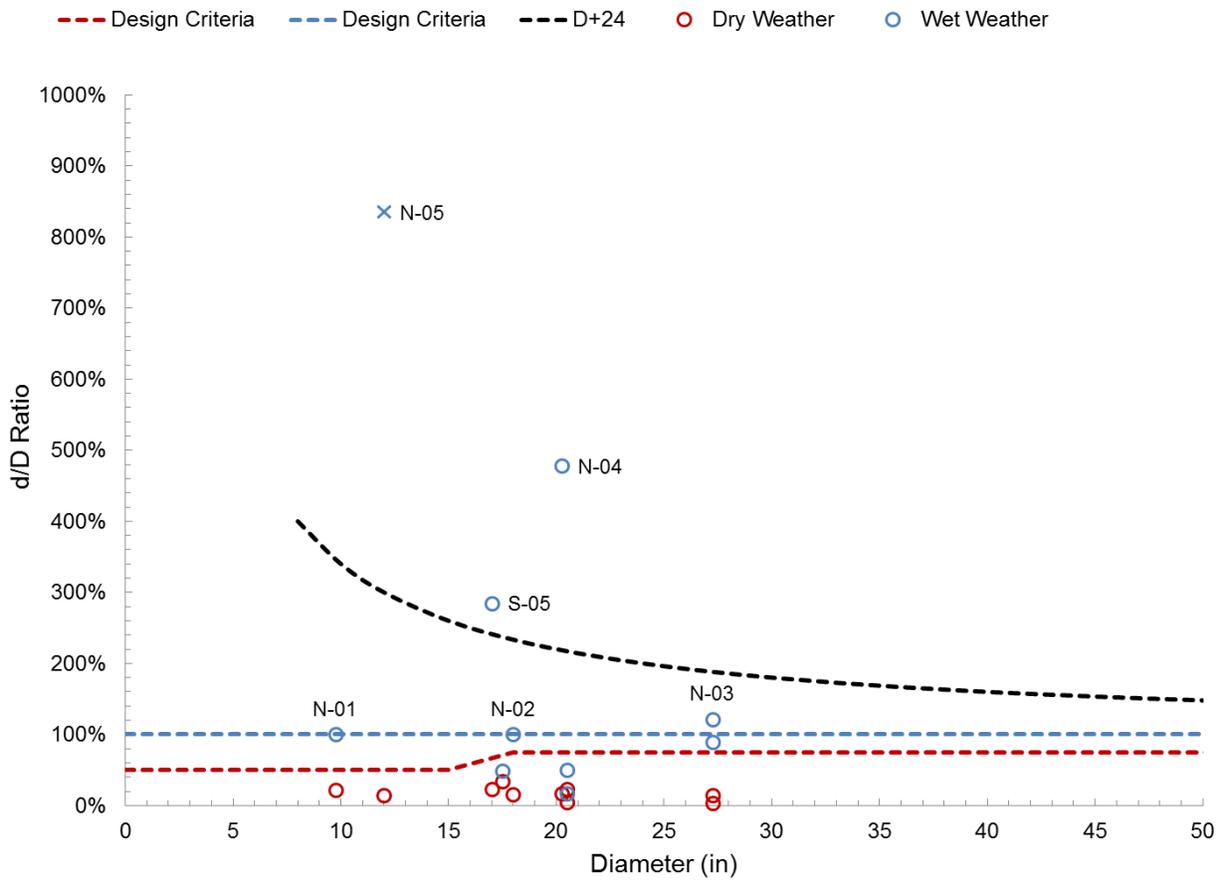
Table 3: Dry and Wet Weather Depth-to-Diameter Ratios

Monitor	D (inches)	d_{max-D} (inches)	d_{max-D} / D (%)	d_{max-W} (inches)	d_{max-W} / D (%)
N-01	9.75	2.13	22%	9.75	100%
N-02	18.0	2.81	16%	18.00	100%
N-03	27.25	3.92	14%	33.14	122%
N-04	20.25	3.40	17%	96.82	478%
N-05	12.0	1.74	15%	100.22	835%
S-01	27.25	1.05	4%	24.32	89%
S-02	20.5	1.03	5%	3.58	17%
S-03	20.5	4.86	24%	10.39	51%
S-04	17.5	6.02	34%	8.57	49%
S-05	17.0	3.85	23%	48.40	285%

The d/D ratio is a performance indicator used to assess sewer capacity. Sewers are often designed to flow under open channel flow conditions with some reserve capacity. As a result, ASCE and WEF recommend that sewers with diameters up to 15 inches be designed to flow with dry weather d/D ratios of 50%, and larger diameter sewers be designed to flow with dry weather d/D ratios of 75%. Sewers are not generally designed to operate under surcharge conditions with wet weather d/D ratios greater than 100%. Observed wet weather d/D ratios are also compared to additional capacity assurance criteria, designed to highlight portions of the sewer system where flow depths are greater than 24 inches above the crown of the sewer (D+24) or are within 36 inches of the manhole rim (R-36). These design and capacity assurance criteria are useful for comparison to observed d/D ratios as shown in Figure 5.



Figure 5: Flow Depth-to-Diameter Ratios Compared to Design Guidance



During dry weather conditions, all of the observed dry weather d/D ratios are within design criteria recommended by ASCE and WEF, indicating that there is sufficient capacity to accommodate dry weather flow rates at these locations.

During wet weather conditions, the observed d/D ratios at sites N-01, S-01, S-02, S-03, and S-04 are less than 100% during the study period and are within design criteria recommended by ASCE and WEF, indicating that there is sufficient capacity to accommodate maximum observed wet weather flows at these locations without surcharge conditions. Site S-02 had a maximum wet weather d/D ratio of exactly 100%. Sites N-03, N-04, N-05, and S-05 had observed d/D ratios greater than 100%, with N-04, N-05, and S-05 exceeding 24 inches above the top of the pipe. Site N-05, which is marked with an “X” on the plot, had a wet weather depth within 36 inches of the manhole rim, but did not exceed the rim elevation.





Self-Cleansing Status

Self-cleansing is an important aspect of sanitary sewer design and is desired to minimize the deposition of silt, sediment, and debris. The Tractive Force Method is used to design sewers to achieve self-cleansing conditions based on a required critical shear stress (τ_c). This method is recommended by ASCE and WEF to evaluate self-cleansing conditions.

The Tractive Force Method can also be extended from the design of new sewers to the evaluation of existing sewers, and was applied to evaluate the self-cleansing status of each flow monitor location during the study period. The maximum dry weather flow depth ($d_{\max-D}$) and flow velocity ($v_{\max-D}$) from each flow monitor location are used to compute the actual shear stress (τ) observed at the maximum dry weather flow rate ($Q_{\max-D}$). The results are compared to a threshold self-cleansing range, resulting in a classification of observed flow conditions. Silt observations recorded during the study period are also provided for comparison, and the results are provided in Table 4.

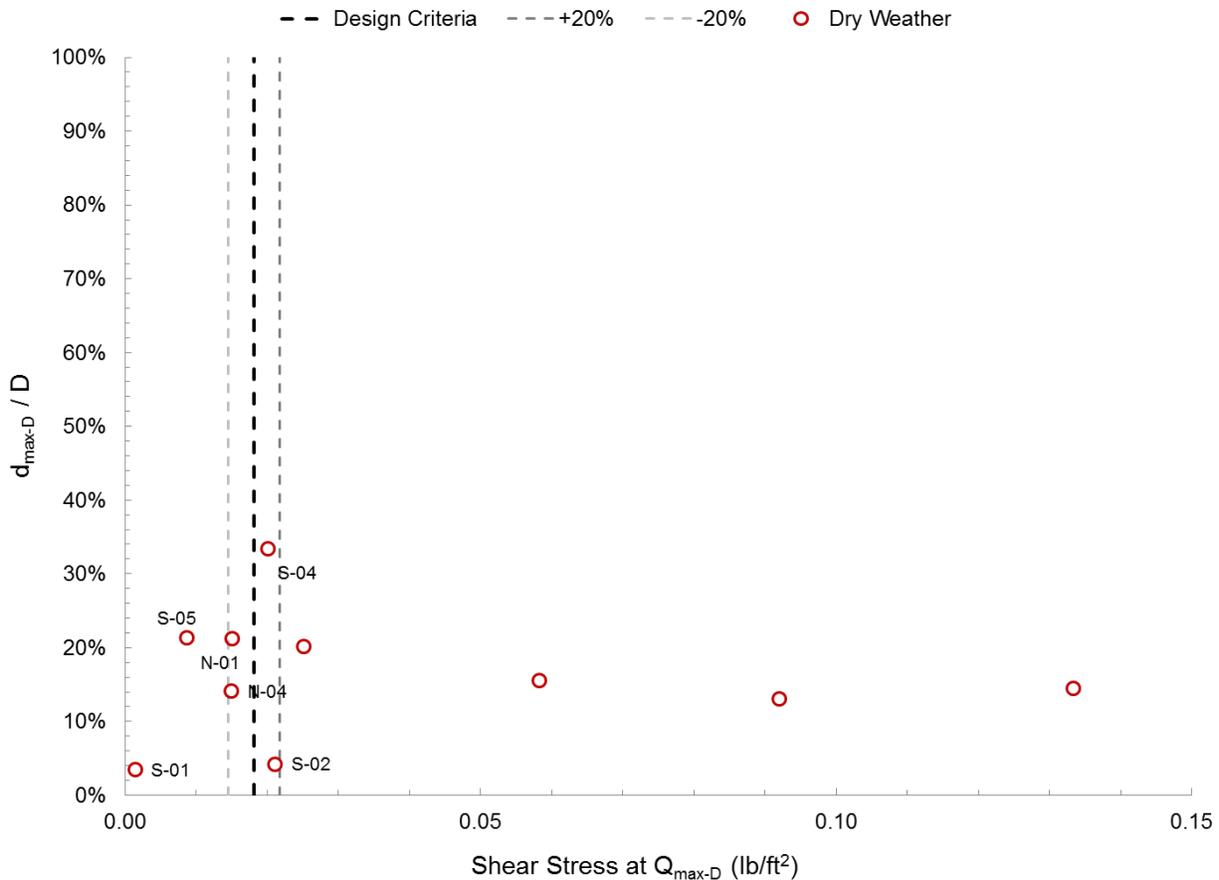
Table 4: Self-Cleansing Classification

Monitor	D (in)	$d_{\max-D}$ (in)	$v_{\max-D}$ (ft/s)	τ (lb/ft ²)	Classification	Silt (in)
N-01	9.75	2.13	1.22	0.0150	2	—
N-02	18.0	2.81	2.53	0.0582	1	—
N-03	27.25	3.92	3.37	0.0921	1	—
N-04	20.25	3.40	1.32	0.0149	2	—
N-05	12.0	1.74	3.54	0.1333	1	—
S-01	27.25	1.05	0.33	0.0013	3	—
S-02	20.5	1.03	1.30	0.0211	2	—
S-03	20.5	4.86	1.81	0.0252	1	—
S-04	17.5	6.02	1.66	0.0201	2	—
S-05	17.0	3.85	1.02	0.0086	3	—

The required critical shear stress recommended by ASCE and WEF for application of the Tractive Force Method is 0.0181 lb/ft². The actual shear stress achieved under normal dry weather conditions is compared to this design guidance in Figure 6. Sewers predicted to be self-cleansing are shown to the right of the recommended critical shear stress, and sewers predicted to be non-cleansing are shown to the left. Research by ADS has shown that the transition from self-cleansing to non-cleansing generally occurs within $\pm 20\%$ of this recommended value. As a result, the hydraulic conditions at each flow monitor location are classified as Class 1 – Self-Cleansing, Class 2 – Marginal Cleansing, or Class 3 – Non-Cleansing.



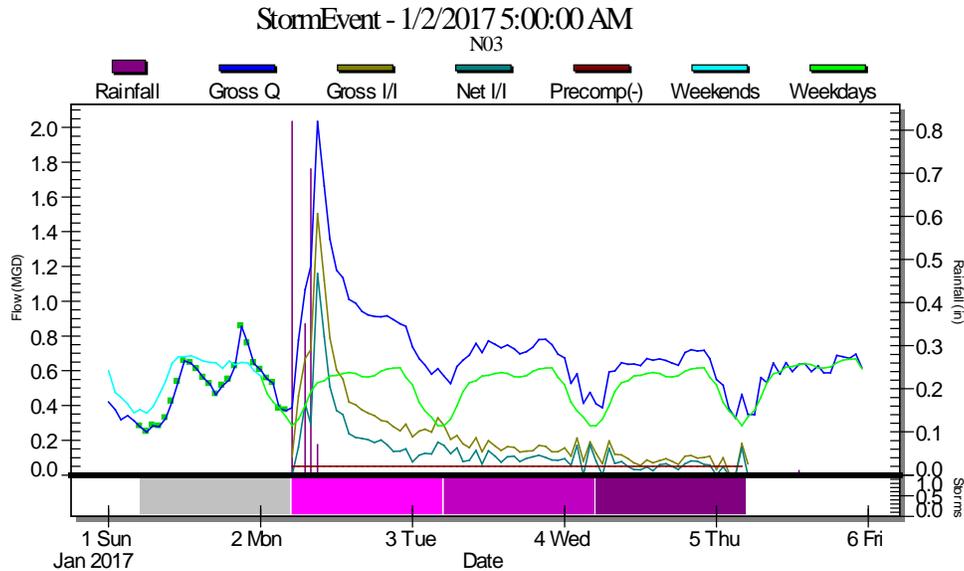
Figure 6: Self-Cleansing Status Compared to Design Guidance



Based on hydraulic conditions observed during the study period, sites N-02, N-3, N-05, and S-03 are defined as Class 1 – Self-Cleansing. Sites N-01, N-04, S-02, and S-04 are defined as Class 2 – Marginal Cleansing. Sites S-01 and S05 are defined as Class 3 – Non-Cleansing.

Rainfall-Dependent Inflow and Infiltration

During wet weather events, significant amounts of extraneous water can enter a sewer system, resulting in sanitary sewer overflows (SSOs), basement backups, and/or problems at the wastewater treatment plant (WWTP). A comparison of flow monitor data from dry weather and wet weather periods provides a quantification of rainfall-dependent inflow and infiltration (RDII), which is calculated by subtracting the measured flow during a rainfall event from the flow during an average dry day in the study period. A wet weather storm decomposition hydrograph is provided in Figure 7. The storm event is depicted by the purple bands, and a precompensation period prior to the storm is depicted by the light gray band. Adjustments to the average dry day pattern are made as needed to account for antecedent conditions prior to each storm event.

**Figure 7: Storm Decomposition Hydrograph**

Three storm events of interest were observed and evaluated for each flow monitor basin during the study period, with cumulative rainfall totals between 1.95 and 4.36 inches. Storm decomposition hydrographs are provided in Appendix C for each flow monitor location during each storm event and show the observed responses to rainfall during the study period. A summary of the storm events observed during the study is shown below in Table 5.

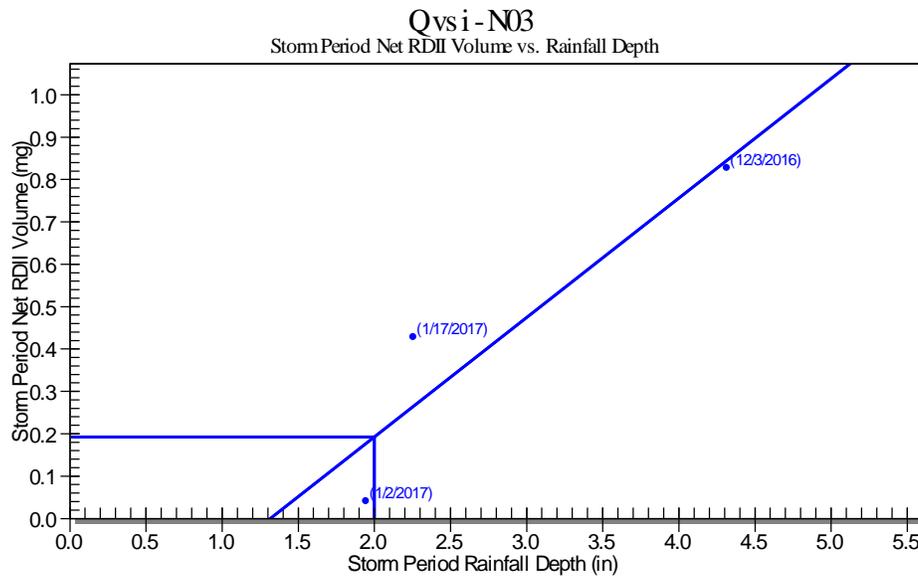
Table 5: Storm Summary

Date	Duration (min)	Duration (hours)	NRG-01 (inches)
12/3/2016	3480	58	4.36
1/02/2017	240	4	1.95
1/17/2017	2100	35	2.64

After the RDII calculations are determined for each storm event, the results are plotted as a function of rainfall total. An example is shown in Figure 8 in which the relationship between the Storm Event RDII (MG) is plotted with respect to the Storm Event rainfall (inches) for each storm event. These relationships can then be used to evaluate the consistency of rainfall responses within the sanitary sewer system and estimate the RDII response for various rainfall amounts. RDII vs. rainfall graphs for each flow monitor basin are provided in Appendix C.



Figure 8: RDII Response vs. Rainfall Depth



Based on the results obtained during the study period, Net RDII are reported for each flow monitor for each storm event at the request of the Engineer. Net RDII volumes are computed by subtracting the Gross RDII volume of any upstream flow monitor basin from the Gross RDII volume measured at the outlet of each flow monitor basin. This process identifies and isolates RDII to the basin sizes shown in Table 1. Normalized Net RDII is then calculated by dividing the net RDII volume by the associated basin size, and the results are shown in Table 6.

Table 6: Normalized RDII (Gal/LF) for All Storm Events

Meter	12/03/2018	01/02/2017	01/17/2017
N-01	16.94	4.99	6.15
N-02	21.67	3.99	7.52
N-03	15.47	5.46	7.40
N-04	5.58	2.57	3.68
N-05	67.60	33.37	13.42
S-01	0.69	1.14	5.55
S-02	18.88	5.65	7.24
S-03	6.47	8.55	17.58
S-04	20.70	2.29	4.88
S-05	2.26	1.65	1.65



These Normalized RDII values are then normalized per inch of rain by dividing the values in Table 6 for each meter for each storm by the total inches of rain in each event. These values are provided in Table 7.

Table 7: Normalized RDII (Gal/LF/in) for All Storm Events

Meter	12/03/2018	01/02/2017	01/17/2017
N-01	3.89	2.56	2.33
N-02	4.97	2.05	2.85
N-03	3.55	2.80	2.80
N-04	1.28	1.32	1.39
N-05	15.51	17.11	5.08
S-01	0.16	0.58	2.10
S-02	4.33	2.90	2.74
S-03	1.48	4.38	6.66
S-04	4.75	1.17	1.85
S-05	0.52	0.84	0.62

Based on the analysis, Site N-05 was the highest (worst) ranked basin during the study period, followed by Site S-03. Site N-05 appears to have had some kind of blockage immediately before the storm on 1/2/2017, but it also went into surcharge conditions during the storm on 12/3/2016. After S-03, Sites N-01, N-02, N-03, and S-02 all had similar values for RDII per linear foot and per inch of rain.



Conclusions and Recommendations

The conclusions and recommendations in this study are based on data gathered using 10 temporary flow monitors and three temporary rain gauges. The study period was conducted from 11/29/2016 and continued through 2/6/2017, a total duration of 69 days. Three rain events of interest were observed for each flow monitor during the study period, with rainfall totals ranging from 1.95 inches to 4.34 inches. A detailed analysis of dry weather and wet weather periods was performed and included an evaluation of various key performance indicators. Specific recommendations for further planning, evaluation, or condition assessment activities are provided below:

Dry Weather Performance

During dry weather conditions, all of the observed dry weather d/D ratios are within design criteria recommended by ASCE and WEF, indicating that there is sufficient capacity to accommodate dry weather flow rates at these locations.

Based on hydraulic conditions observed during the study period, sites N-02, N-3, N-05, and S-03 are defined as Class 1 – Self-Cleansing. Sites N-01, N-04, S-02, and S-04 are defined as Class 2 – Marginal Cleansing. Sites S-01 and S-05 are defined as Class 3 – Non-Cleansing. Class 3 sewers should be inspected periodically by the City as part of a preventive sewer cleaning program to determine the frequency of cleaning needed at these locations.

Wet Weather Performance

The largest gross peaking factor observed during the study period was a value of 56.38 at Site S-01. The large peaking factor is partially attributable to a very low average dry day flow at this site. Wet weather peaking factors at the remaining flow monitor locations ranged from 1.88 to 11.60. Flow increases at all flow monitor locations occur quickly during wet weather events and then gradually return to normal. This behavior suggests the presence of traditional inflow and infiltration sources.

During wet weather conditions, the observed d/D ratios at sites N-01, S-01, S-02, S-03, and S-04 are less than 100% during the study period and are within design criteria recommended by ASCE and WEF, indicating that there is sufficient capacity to accommodate maximum observed wet weather flows at these locations without surcharge conditions. Site S-02 had a maximum wet weather d/D ratio of exactly 100%. Sites N-03, N-04, N-05, and S-05 had observed d/D ratios greater than 100%, with N-04, N-05, and S-05 exceeding 24 inches above the top of the



pipe. Site N-05 had a wet weather depth within 36 inches of the manhole rim, but did not exceed the rim elevation.

Rainfall-Dependent Inflow and Infiltration

Based on the analysis, Site N-05 was the highest (worst) ranked basin during the study period, followed by Site S-03. Site N-05 appears to have had some kind of blockage immediately before the storm on 1/2/2017, but it also went into surcharge conditions during the storm on 12/3/2016. After S-03, Sites N-01, N-02, N-03, and S-02 all had similar values for RDII per linear foot and per inch of rain.

ADS recommends condition assessment activities – including manhole inspections, smoke testing, and CCTV inspections – within these areas to identify individual sources of inflow and infiltration.



Definitions

Basin – a designation given to a series of interconnected sewers within a sanitary sewer system that collect and convey wastewater to a common manhole or pump station. The size and geographic extent of a given basin are system specific. Basin designations are established to provide a consistent nomenclature for system components to facilitate effective planning, operation, and maintenance.

CCTV Inspection – a common diagnostic method used to visually inspect and document the general location, connectivity, and condition of a sewer. CCTV inspection is accomplished using a variety of specially designed camera systems.

Depth-to-Diameter (d/D) Ratio – a ratio of maximum flow depth to sewer diameter. d/D ratios are often calculated to describe both dry weather and wet weather periods and are one measure used to assess sewer capacity utilization. In this study, d/D ratios are computed using hourly average data.

Infiltration – water that enters a sanitary sewer system from the ground through defective system components including, but not limited to, defective sewers, manholes, service connections, or other system appurtenances. Infiltration is primarily dependent upon groundwater elevations, but may also be influenced by storm events and leaking water mains.

Inflow – storm water runoff that enters a sanitary sewer system from direct connections including, but not limited to, building downspouts, clean-outs, foundation drains, sump pumps, basement and area drains, and cross connections with storm sewer systems.

Manhole Inspection – a common diagnostic method used to visually inspect and document the location and condition of a manhole. Manhole inspection can be accomplished using confined space entry or non-entry techniques.

Peaking Factor (PF) – a ratio of maximum flow rate to average flow rate. Peaking factors are often calculated to describe both dry weather and wet weather periods, where maximum flow rates are compared to average dry weather flow rates. In this study, peaking factors are computed using hourly average data.

Rain-Dependent Inflow and Infiltration (RDII) – the collective inflow and infiltration that enter a sewer system as a direct result of rainfall.

Sanitary Sewer Overflow (SSO) – a discharge of untreated wastewater from a sanitary sewer system, caused by a variety of reasons including, but not limited to, inadequate sewer design and construction, insufficient operation and maintenance, power failures, and vandalism.



Sanitary Sewer System – a collection of sewers, manholes, pump stations, and other appurtenances designed for the collection and transportation of wastewater.

Sewer Cleaning – a common method used to dislodge and remove accumulated debris, grease, and roots within a sewer line to achieve desired conditions for CCTV inspection. Under routine conditions, sewer cleaning is performed using hydraulic jetting and vacuum debris removal techniques.

Smoke Testing – a common diagnostic method used to locate and identify potential infiltration and inflow sources within a sanitary sewer system. During smoke testing, a special non-toxic, non-staining smoke is blown into a selected portion of the system. Potential infiltration and inflow sources are evidenced by visible smoke.

Tractive Force Method – a method used to evaluate the self-cleansing status of gravity sewers. This approach is recommended by the American Society of Civil Engineers and the Water Environment Federation.



References

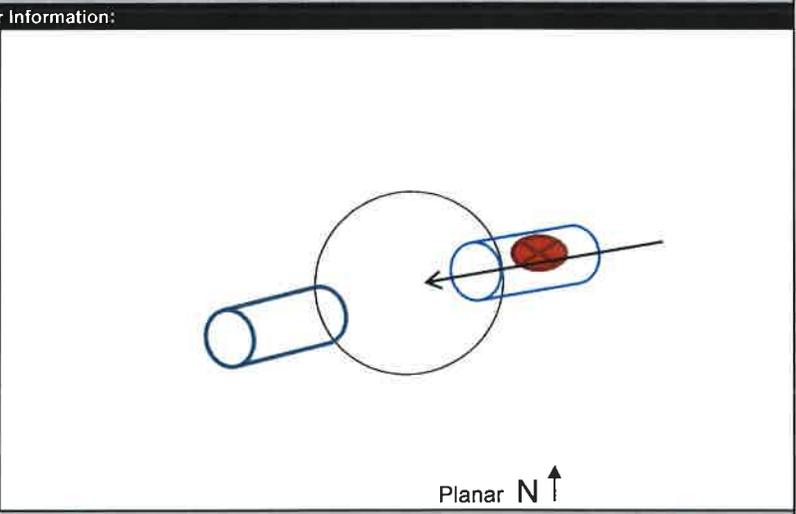
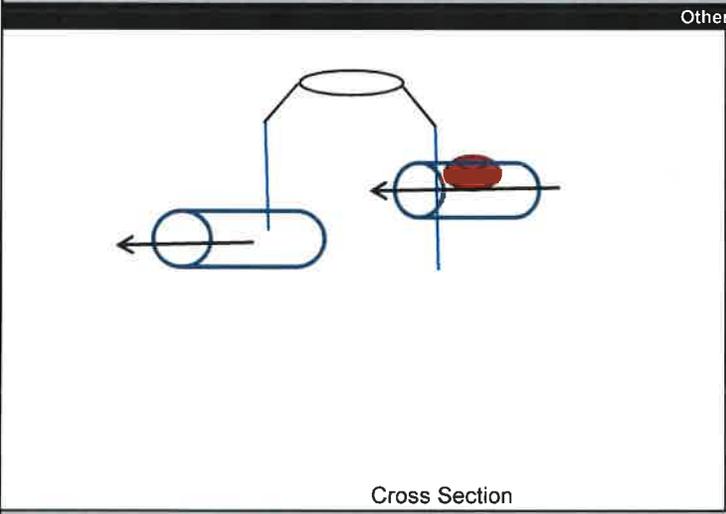
1. Bizier, Paul, Editor (2007). *Gravity Sanitary Sewer Design and Construction*, ASCE Manuals and Reports on Engineering Practice No. 60, American Society of Civil Engineers: Reston, VA.
2. Enfinger, K.L. and Stevens, P.L. (2006). "Scattergraph Principles and Practice – Tools and Techniques to Evaluate Sewer Capacity," *Proceedings of the Pipeline Division Specialty Conference*; Chicago, IL; American Society of Civil Engineers: Reston, VA.
3. Enfinger, K.L. and Mitchell, P.S. (2010). "Scattergraph Principles and Practice – Evaluating Self-Cleansing in Existing Sewers Using the Tractive Force Method," *Proceedings of the World Environmental and Water Resources Congress*; Providence, RI. American Society of Civil Engineers: Reston, VA.
4. Hershfield, David M. et al (1961). Technical Paper No. 40, Rainfall Frequency Atlas Of The United States. U.S. Government Printing Office. Washington, D. C.
5. Mitchell, P.S., Stevens, P.L., and Nazaroff, A. "Quantifying Base Infiltration in Sewers – A comparison of Methods and a Simple Empirical Solution"

Appendix A – Flow Monitor Site Installation Details

Project Name: TOMBALL		City/State: TOMBALL, TX		FM Initials: DM	
Site Name: N-01		Monitor Series:		Monitor S/N#:	
Address / Location: 3 MANHOLES EAST OF 511 HUFSMITH ROAD		Manhole #:		Map Page #:	
Access: DITCH 20' OFF ROAD	Type of System:	Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Combined <input type="checkbox"/>	Pipe Height: 9.75"
					Pipe Width: 9.75"
					Phone Number:



		Manhole Information:			
Date/Time of Investigation:	11/08/2016 15:10:00 PM	Manhole Depth:	9.7	Feet	
Site Hydraulics:	GOOD Drop Into Manhole	Manhole Material / Condition:	Concrete		
Upstream Input: (L/S, P/S)		Pipe Material / Condition:	PVC	Good	
Upstream Manhole:	SOME DEBRIS AT THE INVERT	Mini System Character:	Residential <input checked="" type="checkbox"/>	Commercial <input checked="" type="checkbox"/>	Industrial <input type="checkbox"/>
Downstream Manhole:	Semi-Surcharged	Telephone Information:	N/A		
Depth of Flow (Wet Dof):	1.5 +/- 0.25	Access Pole #:	N/A		
Range (Air Dof):	+/-	Distance From Manhole:	N/A	Feet	
Peak Velocity:	1.2 f/s	Road Cut Length:	N/A	Feet	
Silt:	0 Inches	Trenche Length:	N/A	Feet	

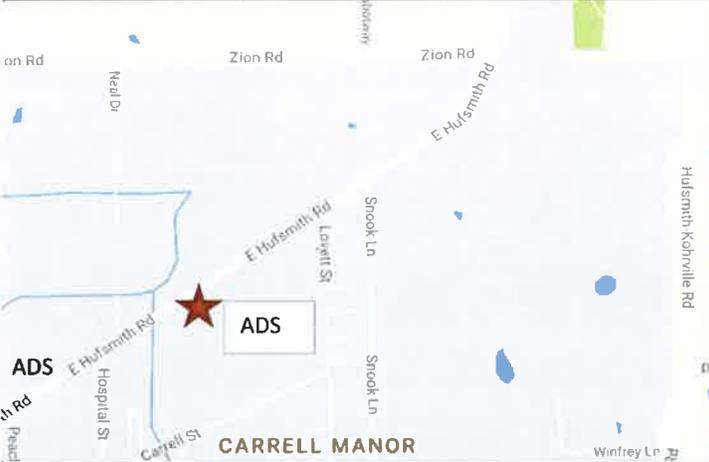


Installation Information		Backup	Yes	No	?	Distance
Installation Type:		Trunk		X		
Sensors / Devices:	CS4	Lift/Pump Station		X		
Surcharge Height:	8 Feet	WWTP			X	2000 ft
Rain Gauge Zone:		Other		X		

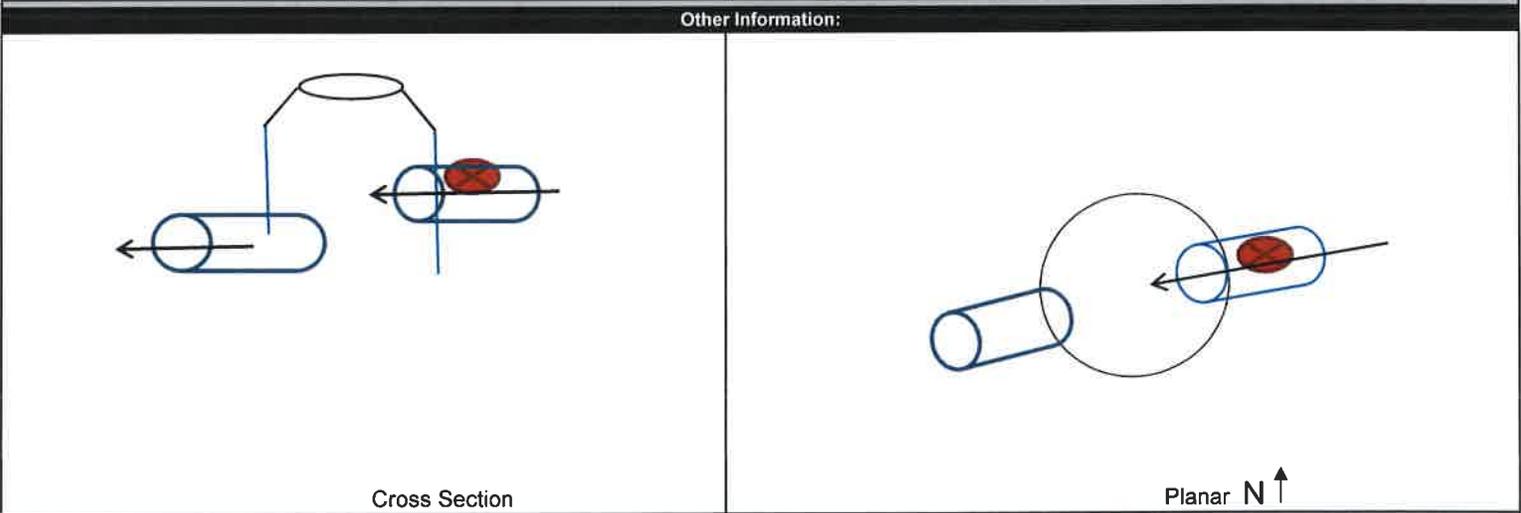
Additional Site Information / Comments:

GPS: N30.1086 W-95.6092 Note: Install sensor 12-15" us to avoid drawdown

Project Name: TOMBALL		City/State: TOMBALL, TX		FM Initials: DM	
Site Name: N-01		Monitor Series:		Monitor S/N#:	
Address / Location: 3 MANHOLES EAST OF 511 HUFSMITH ROAD				Manhole #:	
Access: DITCH 20' OFF ROAD				Map Page #:	
Type of System:		Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Pipe Height: 9.75"	
		Combined <input type="checkbox"/>		Pipe Width: 9.75"	
Phone Number:					



Date/Time of Investigation: 11/08/2016 15:10:00 PM		Manhole Depth: 9.7 Feet	
Site Hydraulics: GOOD Drop Into Manhole		Manhole Material / Condition: Concrete	
Upstream Input: (L/S, P/S)		Pipe Material / Condition: PVC Good	
Upstream Manhole: SOME DEBRIS AT THE INVERT		Mini System	Residential <input checked="" type="checkbox"/>
Downstream Manhole: Semi-Surcharged		Commercial <input checked="" type="checkbox"/>	Industrial <input type="checkbox"/>
		Other <input type="checkbox"/>	
Telephone Information: N/A			
Depth of Flow (Wet Dof): 1.5	+/- 0.25	Access Pole #:	N/A
Range (Air Dof):	+/-	Distance From Manhole:	N/A Feet
Peak Velocity: 1.2	fps	Road Cut Length:	N/A Feet
Silt: 0	Inches	Trenche Length:	N/A Feet



Installation Information		Backup	Yes	No	?	Distance
Installation Type:		Trunk		<input checked="" type="checkbox"/>		
Sensors / Devices:	CS4	Lift/Pump Station		<input checked="" type="checkbox"/>		
Surcharge Height:	8 Feet	WWTP			<input checked="" type="checkbox"/>	2000 ft
Rain Gauge Zone:		Other		<input checked="" type="checkbox"/>		

Additional Site Information / Comments:

GPS: N30.1086 W-95.6092 Note: Install sensor 12-15" us to avoid drawdown



ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: **Tomball** Site ID: **N-01** Site Classification(see below) **1**

* Hazards found at this site (Discuss Checked items below)

Type	#	Specific Hazard	
Communic	1	The site is in a communications "Dead-Zone"	<input type="checkbox"/>
Traffic	2	The site is located in or adjacent to an intersection	<input type="checkbox"/>
	3	The site is located on a hill, curve, or where motorists visibility of the site or other vehicles is reduced	<input type="checkbox"/>
	4	The site is located in a high speed (>45 MPH) or high density roadway	<input type="checkbox"/>
	5	Site traffic is congested at peak hours	<input type="checkbox"/>
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	<input type="checkbox"/>
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	<input type="checkbox"/>
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	<input type="checkbox"/>
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	<input type="checkbox"/>
	10	Work may be performed during darkness; requiring additional site lighting	<input checked="" type="checkbox"/>
	11	Site is located in a high crime area (check with client & local authorities if unsure)	<input type="checkbox"/>
Confined Space	12	Confined Space does not have useable rungs	<input checked="" type="checkbox"/>
	13	Confined Space depth is greater than 50 feet	<input type="checkbox"/>
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	<input type="checkbox"/>
	17	Confined Space subject to surcharge during/after a rain event	<input checked="" type="checkbox"/>
	18	CO, H2S, low O2 or other toxic/flammable gases present or anticipated	<input checked="" type="checkbox"/>
	19	Confined Space has active drop connections	<input type="checkbox"/>

* Hazards found at this site (Discuss Checked items below)

	Class	Description
X	1	2-person crew Standard procedures and equipment. No special requirements
	2	Worksite (non-traffic) with access obstacles and or worksite hazards
	3	Traffic site requiring special scheduling, additional personnel and/or traffic control equipment, or outsourcing
	4	Confined Space Entry requiring special scheduling, additional personnel and/or safety equipment
	5	Special Operation requiring a separate safety plan. Must be approved by Corporate Safety Manager

* Site Specific Safety Requirements, Must Complete for any site Class 2 & Above

TRAFFIC CONTROL PLAN

Note: All workites located in a roadway or immediately adjacent to a roadway where the operation may impede the normal flow of traffic are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

- This worksite does NOT require a traffic control plan
- Standard Traffic Control Plan to be used at this worksite
- This site requires a special Traffic Control Plan which is attached

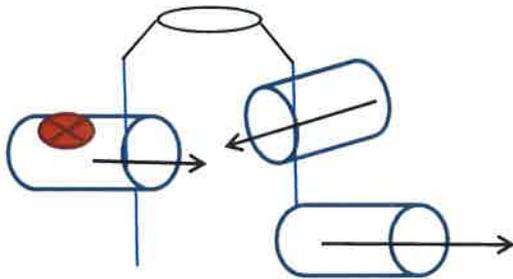
Approved Field Mgr Name: Dennis McPhearson Signature: <i>Dennis McPhearson</i> Date: 8-Nov-16	Reviewed Project Mgr Name: Chuck Franklin Signature: <i>Chuck Franklin</i> Date: 8-Nov-16
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Project Name: TOMBALL		City/State: TOMBALL, TX		FM Initials: DM	
Site Name: N-02		Monitor Series:		Monitor S/N#:	
Address / Location: ACROSS FROM 511 HUFSMITH ROAD				Manhole #:	
				Map Page #:	
Access: STREET	Type of System:	Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Combined <input type="checkbox"/>	Pipe Height: 18"
				Pipe Width: 18"	
				Phone Number:	

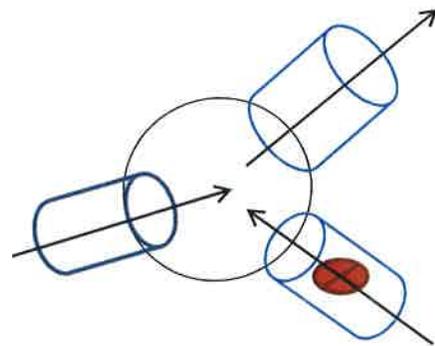


Date/Time of Investigation:	11/08/2016 15:15:00 PM	Manhole Depth:	15.8	Feet
Site Hydraulics:	GOOD	Manhole Material / Condition:	Concrete	
Upstream Input: (L/S, P/S)		Pipe Material / Condition:	Concrete	Good
Upstream Manhole:	Cannot access	Mini System Character:	Residential <input checked="" type="checkbox"/>	Commercial <input checked="" type="checkbox"/>
Downstream Manhole:	Surcharged	Industrial	<input type="checkbox"/>	Other <input type="checkbox"/>
Telephone Information: N/A				
Depth of Flow (Wet Dof):	3.5 +/- 0.25	Access Pole #:	N/A	
Range (Air Dof):	+/-	Distance From Manhole:	N/A	Feet
Peak Velocity:	3.5 fps	Road Cut Length:	N/A	Feet
Silt:	0 inches	Trenche Length:	N/A	Feet

Other Information:



Cross Section



Planar N ↑

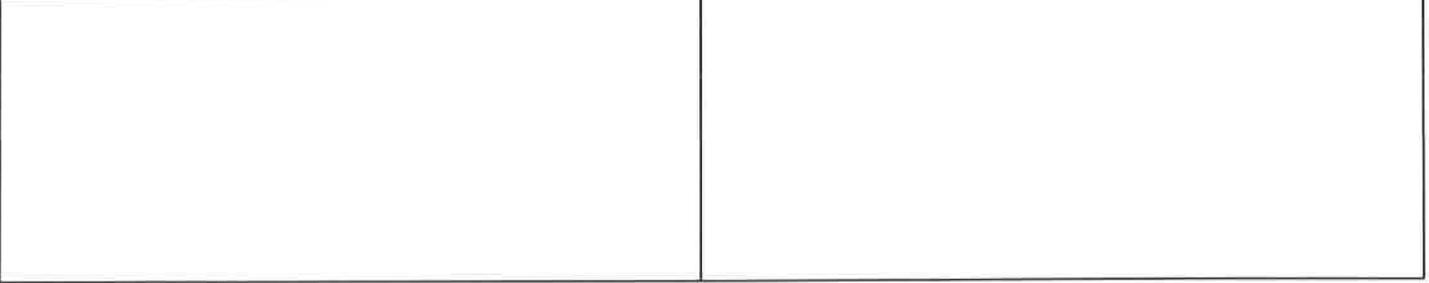
Installation Information		Backup	Yes	No	?	Distance
Installation Type:		Trunk		X		
Sensors / Devices:	CS4	Lift/Pump Station		X		
Surcharge Height:	8 Feet	WWTP			X	2000 ft
Rain Gauge Zone:		Other		X		

Additional Site Information / Comments:

GPS: N30.1082 W-95.6099 Note: Install sensor 18-20" us to avoid drawdown

Project Name: Tomball
Project Number: 25288.11

Site Name: N-02





ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: **Tomball** Site ID: **N-02** Site Classification(see below) **1**

* Hazards found at this site (Discuss Checked items below)

Type	#	Specific Hazard	
Communications	1	The site is in a communications "Dead-Zone"	<input type="checkbox"/>
Traffic	2	The site is located in or adjacent to an intersection	<input type="checkbox"/>
	3	The site is located on a hill, curve, or where motorists visibility of the site or other vehicles is reduced	<input type="checkbox"/>
	4	The site is located in a high speed (>45 MPH) or high density roadway	<input type="checkbox"/>
	5	Site traffic is congested at peak hours	<input type="checkbox"/>
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	<input type="checkbox"/>
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	<input type="checkbox"/>
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	<input type="checkbox"/>
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	<input type="checkbox"/>
	10	Work may be performed during darkness; requiring additional site lighting	<input checked="" type="checkbox"/>
	11	Site is located in a high crime area (check with client & local authorities if unsure)	<input type="checkbox"/>
Confined Space	12	Confined Space does not have useable rungs	<input checked="" type="checkbox"/>
	13	Confined Space depth is greater than 50 feet	<input type="checkbox"/>
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	<input type="checkbox"/>
	17	Confined Space subject to surcharge during/after a rain event	<input checked="" type="checkbox"/>
	18	CO, H2S, low O2 or other toxic/flammable gases present or anticipated	<input checked="" type="checkbox"/>
	19	Confined Space has active drop connections	<input type="checkbox"/>

* Hazards found at this site (Discuss Checked items below)

	Class	Description
X	1	2-person crew. Standard procedures and equipment. No special requirements
	2	Worksite (non-traffic) with access obstacles and or worksite hazards
	3	Traffic site requiring special scheduling, additional personnel and/or traffic control equipment, or outsourcing
	4	Confined Space Entry requiring special scheduling, additional personnel and/or safety equipment
	5	Special Operation requiring a separate safety plan. Must be approved by Corporate Safety Manager

* Site Specific Safety Requirements, Must Complete for any site Class 2 & Above

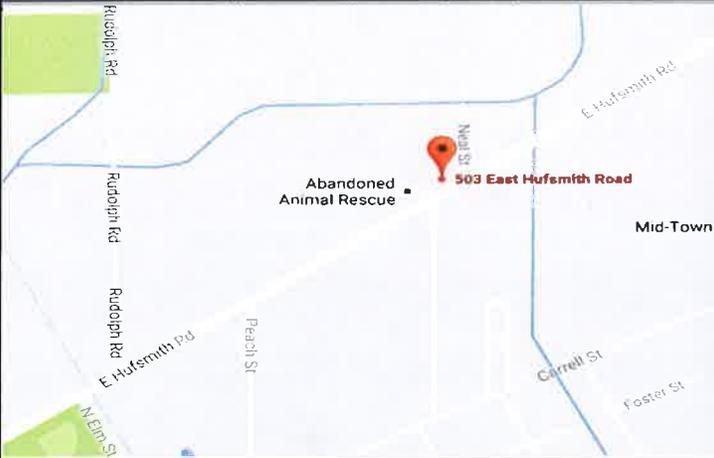
TRAFFIC CONTROL PLAN

Note: All worksites located in a roadway or immediately adjacent to a roadway where the operation may impede the normal flow of traffic are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

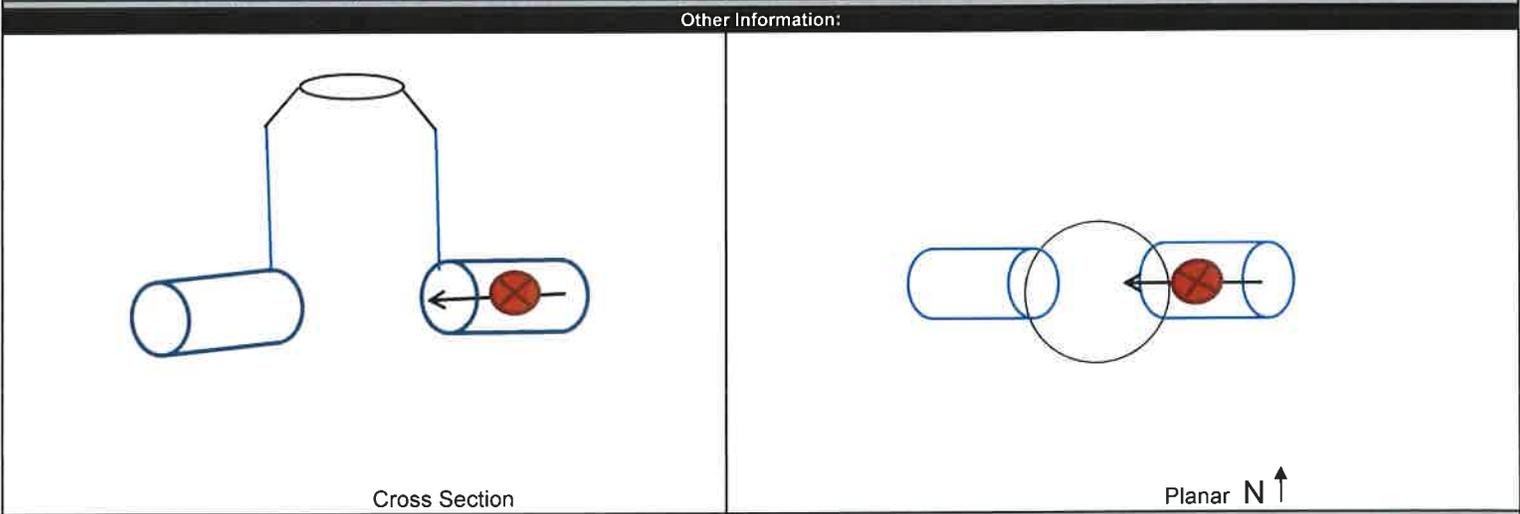
This worksite does NOT require a traffic control plan
 Standard Traffic Control Plan to be used at this worksite
 This site requires a special Traffic Control Plan which is attached

Approved Field Mgr Name: Dennis McPhearson Signature: <i>Dennis McPhearson</i> Date: 8-Nov-16	Reviewed Project Mgr Name: Chuck Franklin Signature: <i>Chuck Franklin</i> Date: 8-Nov-16
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Project Name: TOMBALL		City/State: TOMBALL, TX		FM Initials: DM	
Site Name: N-03		Monitor Series:		Monitor S/N#:	
Address / Location: 11519 HOLDERRIETH RD.				Manhole #:	
				Map Page #:	
Access: Drive		Type of System:	Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Combined <input type="checkbox"/>
		Pipe Height: 27.25			
		Pipe Width: 27.25			
		Phone Number:			



Manhole Information:					
Date/Time of Investigation:	11/8/6 1350		Manhole Depth:	10.5 Feet	
Site Hydraulics:	GOOD		Manhole Material / Condition:	Concrete	
Upstream Input: (L/S, P/S)	DNI		Pipe Material / Condition:	CONCRETE Fair	
Upstream Manhole:	DNI		Mini System	Residential	Commercial
Downstream Manhole:	DNL		Character:	<input checked="" type="checkbox"/>	Industrial
			Telephone Information:	N/A	
Depth of Flow (Wet Dof):	3.75	+/- 0.25	Access Pole #:	N/A	
Range (Air Dof):			Distance From Manhole:	N/A Feet	
Peak Velocity:	3	fps	Road Cut Length:	N/A Feet	
Silt:	1"	Inches	Trenche Length:	N/A Feet	



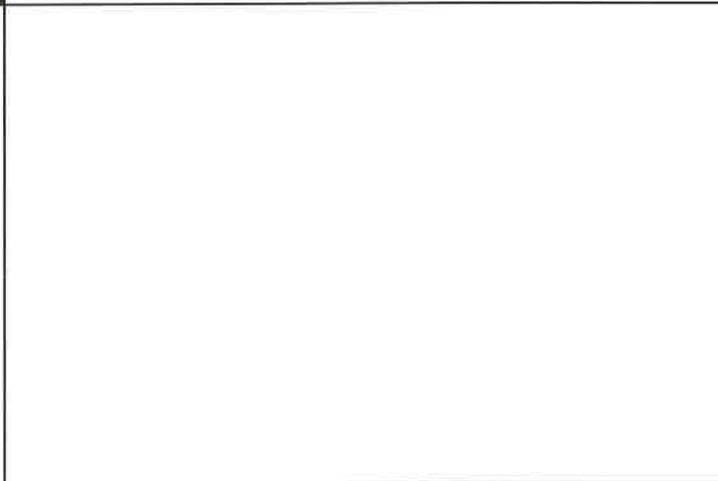
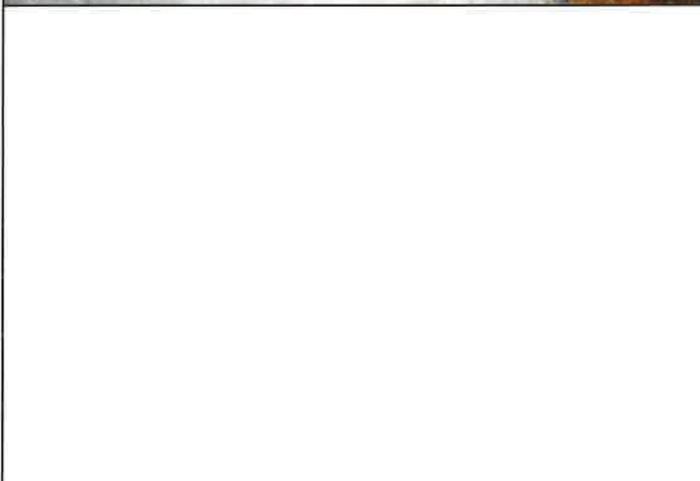
Installation Information		Backup	Yes	Distance
Installation Type:	Ring Crank	Trunk	<input checked="" type="checkbox"/>	
Sensors / Devices:	CS4	Lift/Pump Station	<input checked="" type="checkbox"/>	
Surcharge Height:	15 Feet	WWTP	<input checked="" type="checkbox"/>	3000
Rain Gauge Zone:		Other	<input checked="" type="checkbox"/>	

Additional Site Information / Comments:

GPS: N30°0690 W-95°.5927

Project Name: TOMBALL
Project Number: 25288.11

Site Name: TOMBALL, TX N-03





ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: **TOMBALL** Site ID: **N-03** Site Classification(see below) **1**

* Hazards found at this site (Discuss Checked items below)

Type	#	Specific Hazard	
Communications	1	The site is in a communications "Dead-Zone"	<input type="checkbox"/>
Traffic	2	The site is located in or adjacent to an intersection	<input type="checkbox"/>
	3	The site is located on a hill, curve, or where motorists visibility of the site or other vehicles is reduced	<input type="checkbox"/>
	4	The site is located in a high speed (>45 MPH) or high density roadway	<input type="checkbox"/>
	5	Site traffic is congested at peak hours	<input type="checkbox"/>
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	<input type="checkbox"/>
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	<input type="checkbox"/>
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	<input type="checkbox"/>
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	<input type="checkbox"/>
	10	Work may be performed during darkness; requiring additional site lighting	<input checked="" type="checkbox"/>
	11	Site is located in a high crime area (check with client & local authorities if unsure)	<input type="checkbox"/>
Confined Space	12	Confined Space does not have useable rungs	<input checked="" type="checkbox"/>
	13	Confined Space depth is greater than 50 feet	<input type="checkbox"/>
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	<input type="checkbox"/>
	17	Confined Space subject to surcharge during/after a rain event	<input checked="" type="checkbox"/>
	18	CO, H2S, low O2 or other toxic/flammable gases present or anticipated	<input type="checkbox"/>
	19	Confined Space has active drop connections	<input type="checkbox"/>

* Hazards found at this site (Discuss Checked items below)

	Class	Description
X	1	2-person crew. Standard procedures and equipment. No special requirements
	2	Worksite (non-traffic) with access obstacles and/or worksite hazards
	3	Traffic site requiring special scheduling, additional personnel and/or traffic control equipment, or outsourcing
	4	Confined Space Entry requiring special scheduling, additional personnel and/or safety equipment
	5	Special Operation requiring a separate safety plan. Must be approved by Corporate Safety Manager

* Site Specific Safety Requirements, Must Complete for any site Class 2 & Above

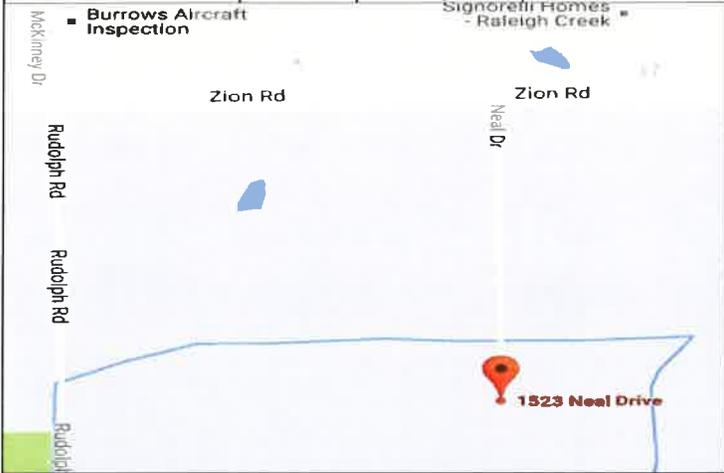
TRAFFIC CONTROL PLAN

Note: All worksites located in a roadway or immediately adjacent to a roadway where the operation may impede the normal flow of traffic are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

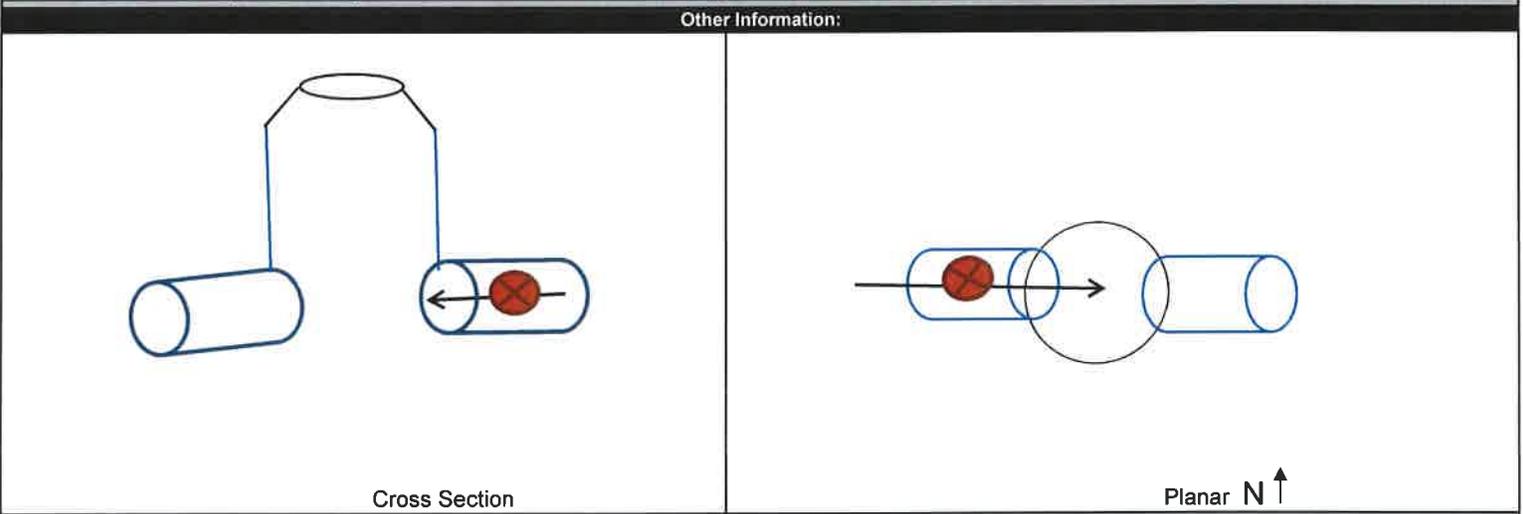
This worksite does NOT require a traffic control plan
 Standard Traffic Control Plan to be used at this worksite
 This site requires a special Traffic Control Plan which is attached

Approved Field Mgr Name: Dennis McPhearson Signature: <i>Dennis McPhearson</i> Date: 8-Nov-16	Reviewed Project Mgr Name: Chuck Franklin Signature: <i>Chuck Franklin</i> Date: 8-Nov-16
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Project Name:	TOMBALL	City/State:	TOMBALL, TX	FM Initials:	DM
Site Name:	N-04	Monitor Series:	Monitor S/N#:		
Address / Location:	1523 NEAL DR		Manhole #:		
			Map Page #:		
Access:	Drive	Type of System:	Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Combined <input type="checkbox"/>
			Pipe Height:	20.25	
			Pipe Width:	20.25	
			Phone Number:		



Manhole Information:					
Date/Time of Investigation:	11/8/06 1:15 PM		Manhole Depth:	14.2	Feet
Site Hydraulics:	GOOD		Manhole Material / Condition:	Concrete	
Upstream Input: (L/S, P/S)	DNI		Pipe Material / Condition:	CONCRETE	Good
Upstream Manhole:	90 DEGREE BEND		Mini System Character:	Residential <input checked="" type="checkbox"/>	Commercial <input type="checkbox"/>
Downstream Manhole:	SLOW HYDRAULICS		Industrial <input type="checkbox"/>	Other <input type="checkbox"/>	
Telephone Information: N/A					
Depth of Flow (Wet Dof):	2.5	+/- 0.25	Access Pole #:	N/A	
Range (Air Dof):		+/-	Distance From Manhole:	N/A	Feet
Peak Velocity:	1.3	fps	Road Cut Length:	N/A	Feet
Silt:		Inches	Trenche Length:	N/A	Feet



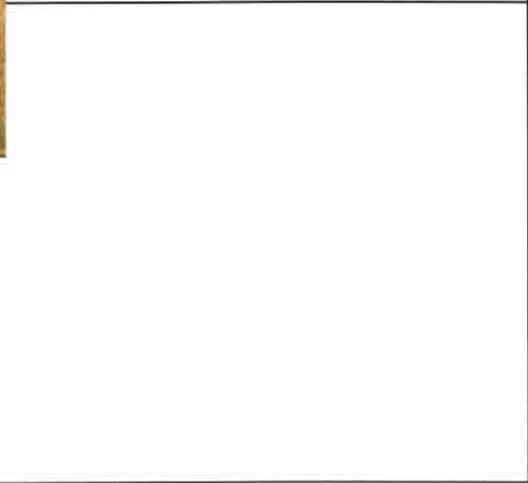
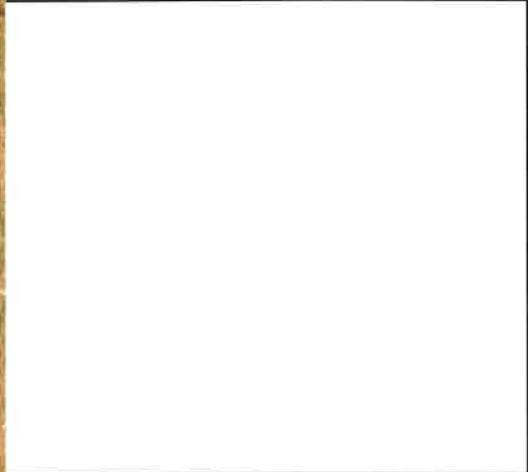
Installation Information		Backup	Yes	Distance
Installation Type:	Ring Crank	Trunk	<input checked="" type="checkbox"/>	
Sensors / Devices:	CS4	Lift/Pump Station	<input checked="" type="checkbox"/>	
Surcharge Height:	15 Feet	WWTP	<input checked="" type="checkbox"/>	3000
Rain Gauge Zone:		Other	<input checked="" type="checkbox"/>	

Additional Site Information / Comments:

GPS: N30°1150 W-95°.6111

Project Name: TOMBALL
Project Number: 25288.11

Site Name: TOMBALL, TX N-04





ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: **TOMBALL** Site ID: **N-04** Site Classification(see below) **1**

* Hazards found at this site (Discuss Checked items below)

Type	#	Specific Hazard	
Communications	1	The site is in a communications "Dead-Zone"	<input type="checkbox"/>
Traffic	2	The site is located in or adjacent to an intersection	<input type="checkbox"/>
	3	The site is located on a hill, curve, or where motorists visibility of the site or other vehicles is reduced	<input type="checkbox"/>
	4	The site is located in a high speed (>45 MPH) or high density roadway	<input type="checkbox"/>
	5	Site traffic is congested at peak hours	<input type="checkbox"/>
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	<input type="checkbox"/>
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	<input type="checkbox"/>
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	<input type="checkbox"/>
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	<input type="checkbox"/>
	10	Work may be performed during darkness; requiring additional site lighting	<input checked="" type="checkbox"/>
Confined Space	11	Site is located in a high crime area (check with client & local authorities if unsure)	<input type="checkbox"/>
	12	Confined Space does not have useable rungs	<input checked="" type="checkbox"/>
	13	Confined Space depth is greater than 50 feet	<input type="checkbox"/>
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	<input type="checkbox"/>
	17	Confined Space subject to surcharge during/after a rain event	<input checked="" type="checkbox"/>
	18	CO, H2S, low O2 or other toxic/flammable gases present or anticipated	<input type="checkbox"/>
	19	Confined Space has active drop connections	<input type="checkbox"/>

* Hazards found at this site (Discuss Checked items below)

	Class	Description
X	1	2-person crew Standard procedures and equipment No special requirements
	2	Worksite (non-traffic) with access obstacles and or worksite hazards
	3	Traffic site requiring special scheduling, additional personnel and/or traffic control equipment, or outsourcing
	4	Confined Space Entry requiring special scheduling, additional personnel and/or safety equipment
	5	Special Operation requiring a separate safety plan. Must be approved by Corporate Safety Manager

* Site Specific Safety Requirements, Must Complete for any site Class 2 & Above

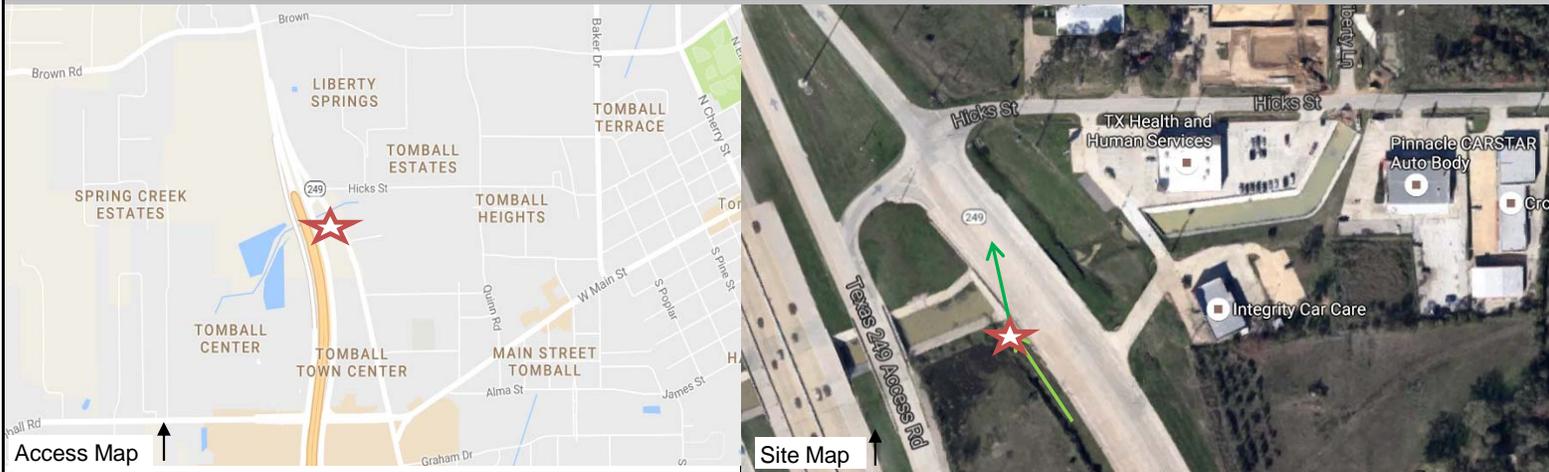
TRAFFIC CONTROL PLAN

Note: All worksites located in a roadway or immediately adjacent to a roadway where the operation may impede the normal flow of traffic are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

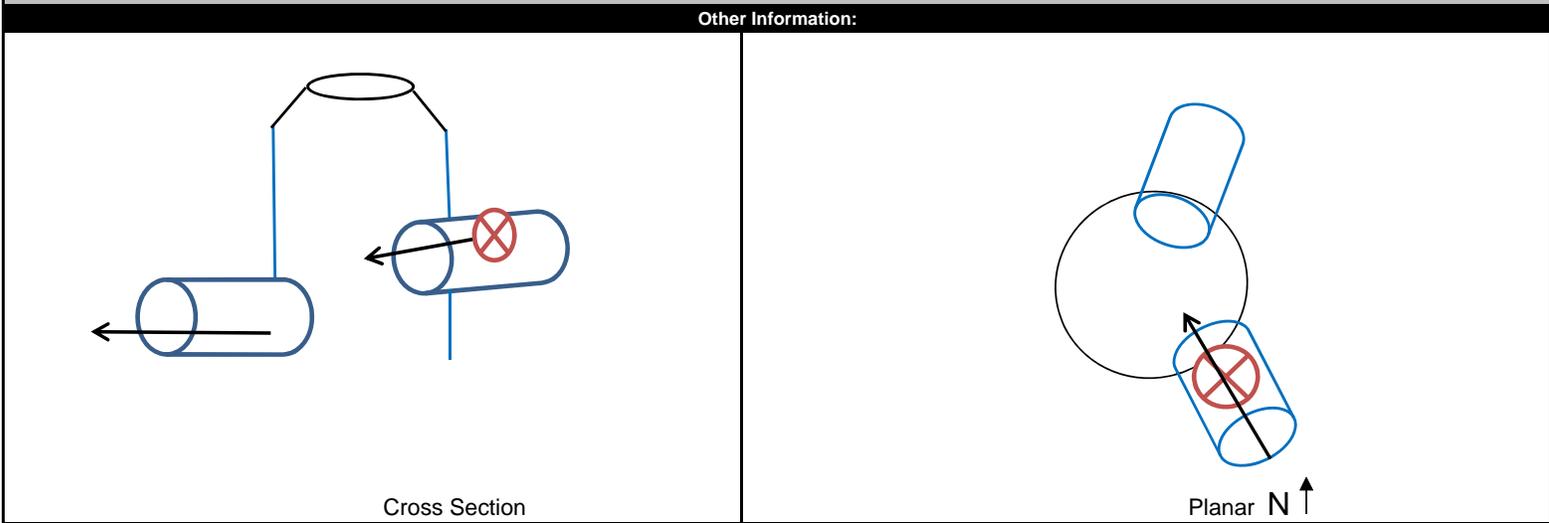
- This worksite does NOT require a traffic control plan
- Standard Traffic Control Plan to be used at this worksite
- This site requires a special Traffic Control Plan which is attached

Approved Field Mgr Name: Dennis McPhearson Signature: <i>Dennis McPhearson</i> Date: 8-Nov-16	Reviewed Project Mgr Name: Chuck Franklin Signature: <i>Chuck Franklin</i> Date: 8-Nov-16
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Project Name: TOMBALL		City/State: TOMBALL, TX		FM Initials:	
Site Name: N-05		Monitor Series: TRITON +		Monitor S/N#: 62993	
Address / Location: 29230 HWY 249				Manhole #:	
Access: Drive				Map Page #:	
Type of System:		Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Combined <input type="checkbox"/>	Pipe Height: 11.75
					Pipe Width: 12
				Phone Number: 107.80.19.139	



		Manhole Information:			
Date/Time of Investigation:	11/28/16 1635	Manhole Depth:	10' 6"	Feet	
Site Hydraulics:	SMOTH/EVEN	Manhole Material / Condition:	Concrete		
Upstream Input: (L/S, P/S)	-	Pipe Material / Condition:	PVC	Fair	
Upstream Manhole:	CNO	Mini System Character:	Residential	Commercial X	Industrial
Downstream Manhole:	Slight backup	Telephone Information:	N/A		
Depth of Flow (Wet Dof):	1.75 +/- 0.25	Access Pole #:	N/A		
Range (Air Dof):	+/-	Distance From Manhole:	N/A	Feet	
Peak Velocity:	4.05 fps	Road Cut Length:	N/A	Feet	
Silt:	0 Inches	Trenche Length:	N/A	Feet	



Installation Information		Backup	Yes	No	?	Distance
Installation Type:	Ring Crank	Trunk		X		
Sensors / Devices:	CS4	Lift/Pump Station		X		
Surcharge Height:	Feet	WWTP		X		
Rain Gauge Zone:		Other		X		

Additional Site Information / Comments:

GPS: N30.096640 W95.635438

Project Name:	TOMBALL	City/State:	TOMBALL, TX	FM Initials:	DM
Site Name:	N-RG01	Monitor Series:		Monitor S/N#:	
Address / Location:	North WWTP, Neal Drive		Map Page #:		

Access:	Drive	Type of System:	Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Combined <input type="checkbox"/>
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Manhole Information:

Date/Time of Investigation:	11/29/2016 16:15:00 PM
Area Characteristics	Open area, no obstructions

Other Information:

Area Picture	Location Picture ↑
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Installation Information	
Installation Type:	Rain Alert II
Sensors / Devices:	8" tipping bucket

Additional Site Information / Comments:

GPS: N30.11135 W-95.61039



ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: **Tomball** Site ID: **N-RG01** Site Classification(see below) **1**

* Hazards found at this site (Discuss Checked items below)

Type	#	Specific Hazard	
Communications	1	The site is in a communications "Dead-Zone"	<input type="checkbox"/>
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	<input type="checkbox"/>
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	<input type="checkbox"/>
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	<input type="checkbox"/>
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	<input type="checkbox"/>
	10	Work may be performed during darkness; requiring additional site lighting	<input type="checkbox"/>
	11	Site is located in a high crime area (check with client & local authorities if unsure)	<input type="checkbox"/>

* Hazards found at this site (Discuss Checked items below)

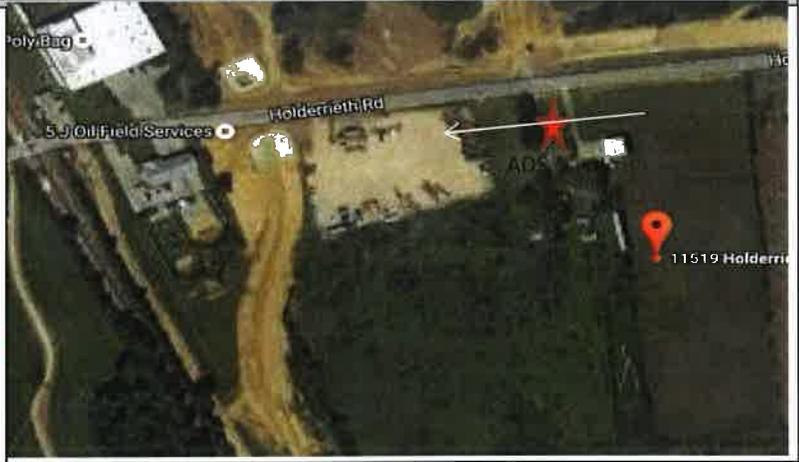
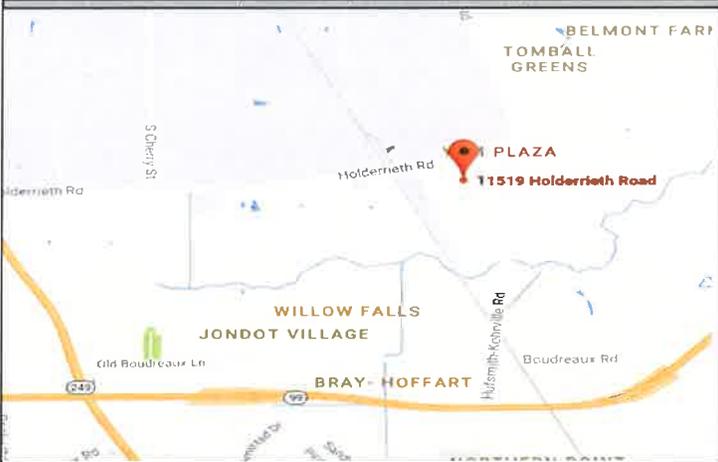
<input type="checkbox"/>	This worksite does not require any access equipment or scheduling
<input type="checkbox"/>	This worksite requires equipment (ladder) for access
<input checked="" type="checkbox"/>	This site requires scheduling access or advanced notice before entering private property

Contact Information **Glen Williams** **832-349-8027**

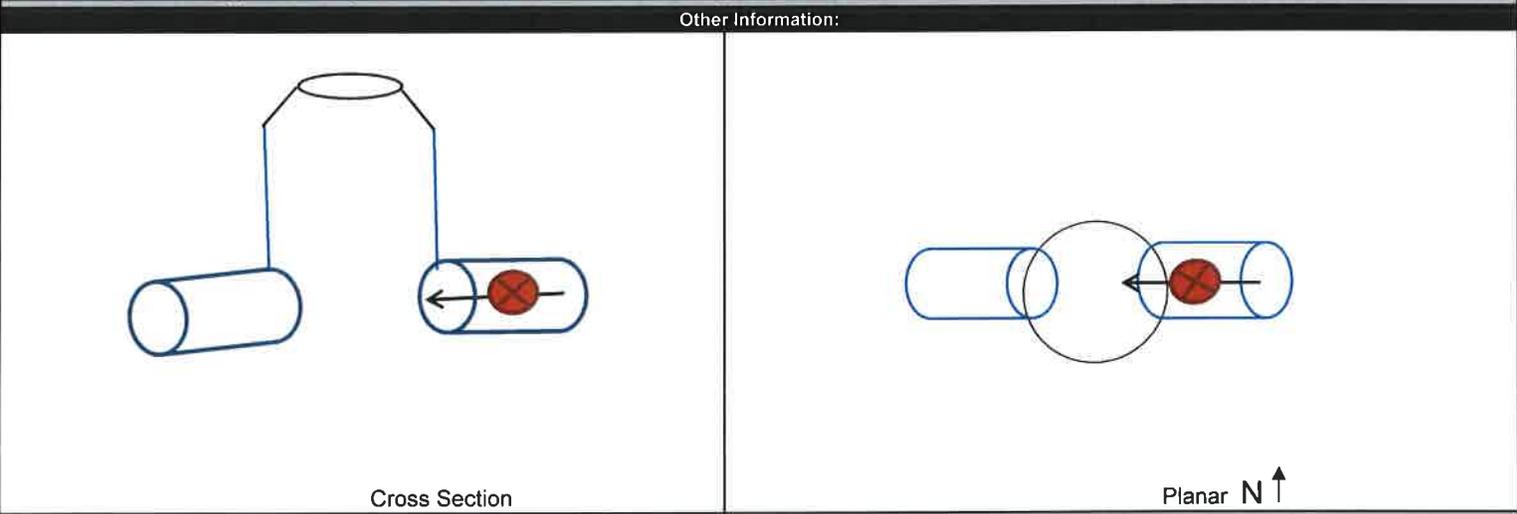
Approved
 Field Mgr Name: **Dennis McPhearson**
 Signature: *Dennis McPhearson*
 Date: **29-Nov-16**

Reviewed
 Project Mgr Name: **Chuck Franklin**
 Signature: *Chuck Franklin*
 Date: **29-Nov-16**

Project Name: TOMBALL		City/State: TOMBALL, TX		FM Initials: DM	
Site Name: S-01		Monitor Series:		Monitor S/N#:	
Address / Location: 11519 HOLDERRIETH RD.				Manhole #:	
				Map Page #:	
Access: Drive	Type of System:	Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Combined <input type="checkbox"/>	Pipe Height: 27.25
				Pipe Width: 27.25	
				Phone Number:	



			Manhole Information:			
Date/Time of Investigation:	11/8/6 1350		Manhole Depth:	10.5 Feet		
Site Hydraulics:	GOOD		Manhole Material / Condition:	Concrete		
Upstream Input: (L/S, P/S)	DNI		Pipe Material / Condition:	CONCRETE		Fair
Upstream Manhole:	DNI		Mini System Character:	Residential <input checked="" type="checkbox"/>	Commercial	Industrial
Downstream Manhole:	DNL		Other			
			Telephone Information: N/A			
Depth of Flow (Wet Dof):	3.75	+/- 0.25	Access Pole #:	N/A		
Range (Air Dof):			Distance From Manhole:	N/A Feet		
Peak Velocity:	3	fps	Road Cut Length:	N/A Feet		
Silt:	1"	Inches	Trenche Length:	N/A Feet		



Installation Information		Backup	Yes	Distance
Installation Type:	Ring Crank	Trunk	<input checked="" type="checkbox"/>	
Sensors / Devices:	CS4	Lift/Pump Station	<input checked="" type="checkbox"/>	
Surcharge Height:	15 Feet	WWTP	<input checked="" type="checkbox"/>	3000
Rain Gauge Zone:		Other	<input checked="" type="checkbox"/>	

Additional Site Information / Comments:

GPS: N30°0690 W-95°.5927

Project Name: Tomball

Project Number: 25288.11

Site Name: S-01





ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: **Tomball** Site ID: **S-01** Site Classification(see below) **1**

* Hazards found at this site (Discuss Checked items below)

Type	#	Specific Hazard	
Communic	1	The site is in a communications "Dead-Zone"	<input type="checkbox"/>
Traffic	2	The site is located in or adjacent to an intersection	<input type="checkbox"/>
	3	The site is located on a hill, curve, or where motorists visibility of the site or other vehicles is reduced	<input type="checkbox"/>
	4	The site is located in a high speed (>45 MPH) or high density roadway	<input type="checkbox"/>
	5	Site traffic is congested at peak hours	<input type="checkbox"/>
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	<input type="checkbox"/>
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	<input type="checkbox"/>
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	<input type="checkbox"/>
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	<input type="checkbox"/>
	10	Work may be performed during darkness; requiring additional site lighting	<input checked="" type="checkbox"/>
Confined Space	11	Sie is located in a high crime area (check with client & local authorities if unsure)	<input type="checkbox"/>
	12	Confined Space does not have useable rungs	<input checked="" type="checkbox"/>
	13	Confined Space depth is greater than 50 feet	<input type="checkbox"/>
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	<input type="checkbox"/>
	17	Confined Space subject to surcharge during/after a rain event	<input checked="" type="checkbox"/>
	18	CO, H2S, low O2 or other toxic/flammable gases present or anticipated	<input type="checkbox"/>
	19	Confined Space has active drop connections	<input type="checkbox"/>

* Hazards found at this site (Discuss Checked items below)

	Class	Description
X	1	2-person crew. Standard procedures and equipment. No special requirements
	2	Worksite (non-traffic) with access obstacles and or worksite hazards
	3	Traffic site requiring special scheduling, additional personnel and/or traffic control equipment, or outsourcing
	4	Confined Space Entry requiring special scheduling, additional personnel and/or safety equipment
	5	Special Operation requiring a separate safety plan. <i>Must be approved by Corporate Safety Manager</i>

* Site Specific Safety Requiremnets, Must Complete for any site Class 2 & Above

TRAFFIC CONTROL PLAN

Note: All worksites located in a roadway or immediately adjacent to a roadway where the operation may impede the normal flow of traffic are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

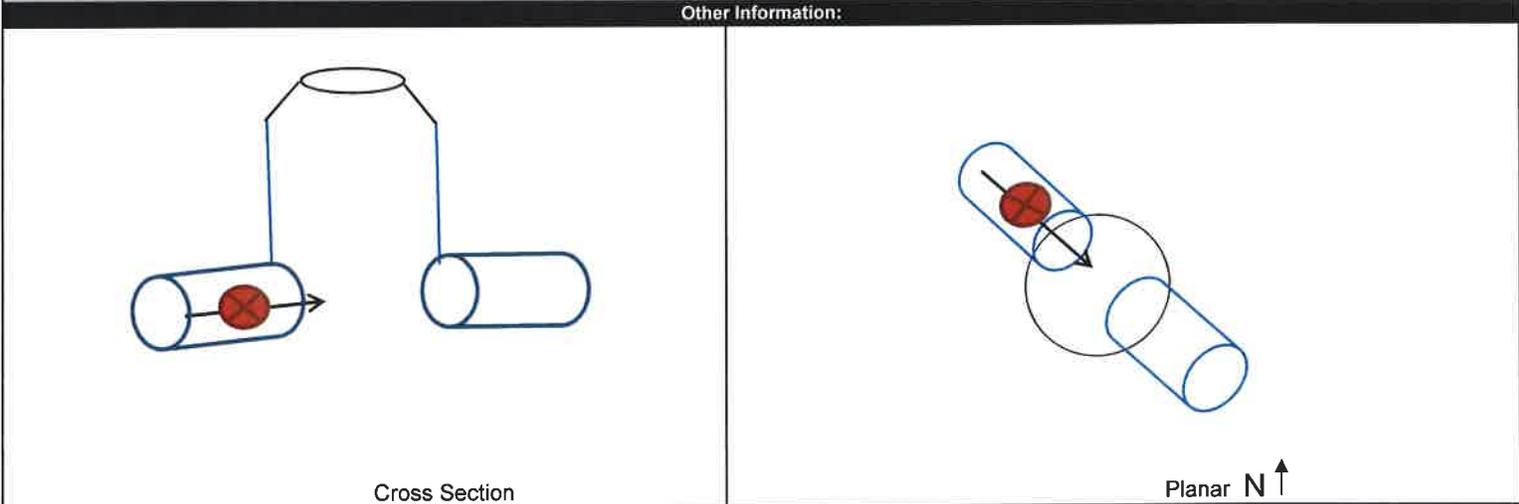
- This worksite does NOT require a traffic control plan
- Standard Traffic Control Plan to be used at this worksite
- This site requires a special Traffic Control Plan which is attached

Approved Field Mgr Name: Dennis McPhearson Signature: <i>Dennis McPhearson</i> Date: 9-Nov-16	Reviewed Project Mgr Name: Chuck Franklin Signature:  Date: 9-Nov-16
------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Project Name: TOMBALL		City/State: TOMBALL, TX		FM Initials: DM	
Site Name: S-02		Monitor Series:		Monitor S/N#:	
Address / Location: 27350 HWY 249				Manhole #:	
				Map Page #:	
Access:	Drive	Type of System:	Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Combined <input type="checkbox"/>
			Pipe Height:	20.5	
			Pipe Width:	20.5	
			Phone Number:		



		Manhole Information:			
Date/Time of Investigation:	11/9/16 1500	Manhole Depth:	15.3	Feet	
Site Hydraulics:	GOOD	Manhole Material / Condition:	Concrete		
Upstream Input: (L/S, P/S)	DNI	Pipe Material / Condition:	PVC	Fair	
Upstream Manhole:	DNI	Mini System Character:	Residential X	Commercial	Industrial
Downstream Manhole:	POOR HYDRAULICS	Telephone Information:	N/A		
Depth of Flow (Wet Dof):	1.25 +/- 0.25	Access Pole #:	N/A		
Range (Air Dof):	+/-	Distance From Manhole:	N/A	Feet	
Peak Velocity:	1 fps	Road Cut Length:	N/A	Feet	
Silt:	Inches	Trenche Length:	N/A	Feet	



Installation Information		Backup	Yes	Distance
Installation Type:	Ring Crank	Trunk	X	
Sensors / Devices:	CS4	Lift/Pump Station	X	
Surcharge Height:	0 Feet	WWTP	X	
Rain Gauge Zone:		Other	X	

Additional Site Information / Comments:

GPS: N30°07'23 W-95°06'25 *LOW FLOW

Project Name: Tomball
Project Number: 25288.11

Site Name: TOMBAL, TX S-02





ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: **TOMBALL** Site ID: **S-02** Site Classification(see below) **1**

* Hazards found at this site (Discuss Checked items below)

Type	#	Specific Hazard	
Communic	1	The site is in a communications "Dead-Zone"	<input type="checkbox"/>
	2	The site is located in or adjacent to an intersection	<input type="checkbox"/>
Traffic	3	The site is located on a hill, curve, or where motorists visibility of the site or other vehicles is reduced	<input type="checkbox"/>
	4	The site is located in a high speed (>45 MPH) or high density roadway	<input type="checkbox"/>
	5	Site traffic is congested at peak hours	<input type="checkbox"/>
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	<input type="checkbox"/>
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	<input type="checkbox"/>
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	<input type="checkbox"/>
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	<input type="checkbox"/>
	10	Work may be performed during darkness; requiring additional site lighting	<input checked="" type="checkbox"/>
Confined Space	11	Sie is located in a high crime area (check with client & local authorities if unsure)	<input type="checkbox"/>
	12	Confined Space does not have useable rungs	<input checked="" type="checkbox"/>
	13	Confined Space depth is greater than 50 feet	<input type="checkbox"/>
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	<input type="checkbox"/>
	17	Confined Space subject to surcharge during/after a rain event	<input checked="" type="checkbox"/>
	18	CO, H2S, low O2 or other toxic/flammable gases present or anticipated	<input type="checkbox"/>
	19	Confined Space has active drop connections	<input type="checkbox"/>

* Hazards found at this site (Discuss Checked items below)

	Class	Description
X	1	2-person crew. Standard procedures and equipment. No special requirements
	2	Worksite (non-traffic) with access obstacles and or worksite hazards
	3	Traffic site requiring special scheduling, additional personnel and/or traffic control equipment, or outsourcing
	4	Confined Space Entry requiring special scheduling, additional personnel and/or safety equipment
	5	Special Operation requiring a separate safety plan. <i>Must be approved by Corporate Safety Manager</i>

* Site Specific Safety Requirements, Must Complete for any site Class 2 & Above

TRAFFIC CONTROL PLAN

Note: All worksites located in a roadway or immediately adjacent to a roadway where the operation may impede the normal flow of traffic are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

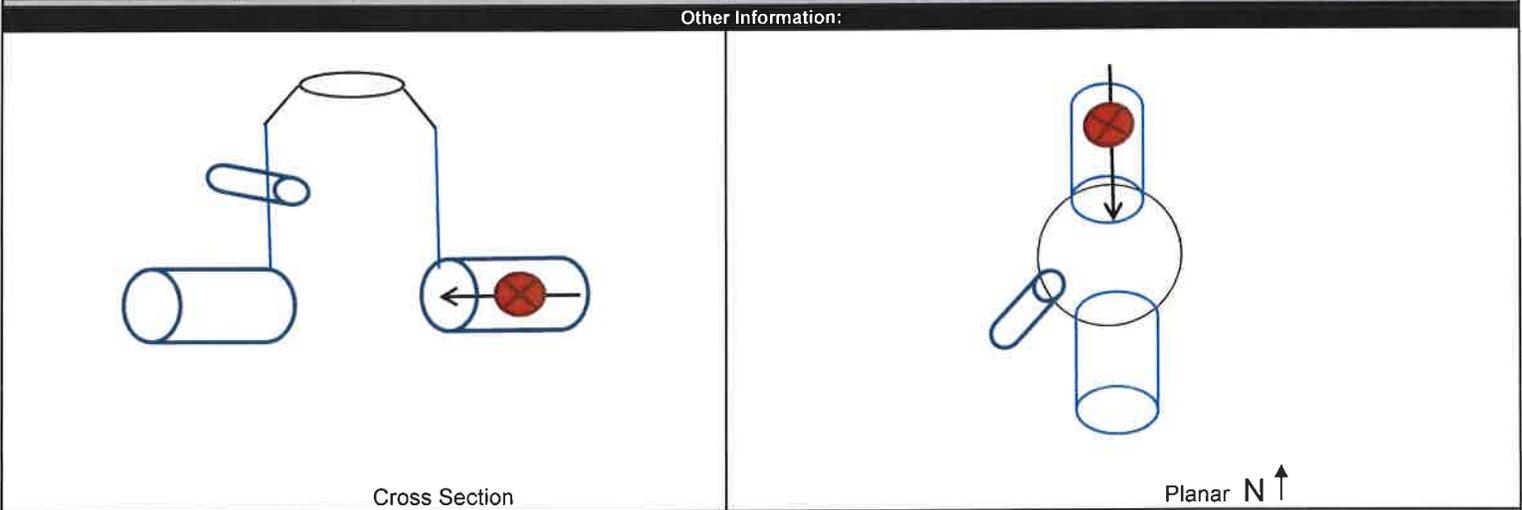
This worksite does NOT require a traffic control plan
 Standard Traffic Control Plan to be used at this worksite
 This site requires a special Traffic Control Plan which is attached

Approved Field Mgr Name: Dennis McPhearson Signature: <i>Dennis McPhearson</i> Date: 9-Nov-16	Reviewed Project Mgr Name: Chuck Franklin Signature: _____ Date: _____
------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------

Project Name: TOMBALL		City/State: TOMBALL, TX		FM Initials: DM	
Site Name: S-03		Monitor Series:		Monitor S/N#:	
Address / Location: 1626 S. CHERRY ST.		Manhole #:		Map Page #:	
Access: Drive	Type of System:	Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Combined <input type="checkbox"/>	Pipe Height: 20.5
					Pipe Width: 20.5
					Phone Number:



Manhole Information:					
Date/Time of Investigation:	11/9/16 1315		Manhole Depth:	18 Feet	
Site Hydraulics:	GOOD		Manhole Material / Condition:	Concrete	
Upstream Input: (L/S, P/S)	DNI		Pipe Material / Condition:	PVC Fair	
Upstream Manhole:	DNI		Mini System Character:	Residential X	Commercial X
Downstream Manhole:	HEAVY DEBRIS		Industrial	Other	
Depth of Flow (Wet Dof):	4.5	+/- 0.25	Telephone Information:	N/A	
Range (Air Dof):	+/-		Access Pole #:	N/A	
Peak Velocity:	2.5	fps	Distance From Manhole:	N/A Feet	
Silt:	Inches		Road Cut Length:	N/A Feet	
			Trenche Length:	N/A Feet	



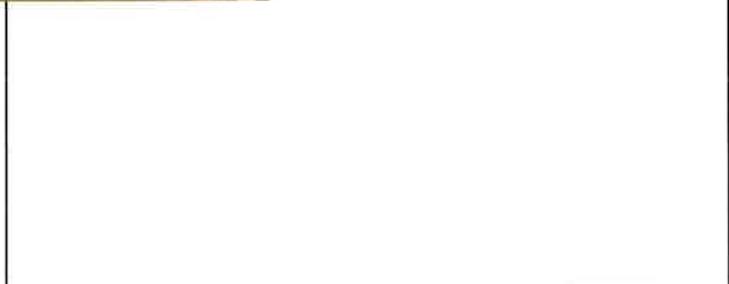
Installation Information		Backup	Yes	Distance
Installation Type:	Ring Crank	Trunk	X	
Sensors / Devices:	CS4	Lift/Pump Station	X	
Surcharge Height:	8 Feet	WWTP		X 2500-3000 FT
Rain Gauge Zone:		Other	X	

Additional Site Information / Comments:

GPS: N30°0806 W-95°.6116

Project Name: TOMBALL
Project Number: 25288.11

Site Name: TOMBAL, TX S-03





ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: **TOMBALL** Site ID: **S-03** Site Classification(see below) **1**

* Hazards found at this site (Discuss Checked items below)

Type	#	Specific Hazard	
Communic	1	The site is in a communications "Dead-Zone"	<input type="checkbox"/>
	2	The site is located in or adjacent to an intersection	<input type="checkbox"/>
Traffic	3	The site is located on a hill, curve, or where motorists visibility of the site or other vehicles is reduced	<input type="checkbox"/>
	4	The site is located in a high speed (>45 MPH) or high density roadway	<input type="checkbox"/>
	5	Site traffic is congested at peak hours	<input type="checkbox"/>
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	<input type="checkbox"/>
	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	<input type="checkbox"/>
Worksite	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	<input type="checkbox"/>
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	<input type="checkbox"/>
	10	Work may be performed during darkness; requiring additional site lighting	<input checked="" type="checkbox"/>
	11	Sie is located in a high crime area (check with client & local authorities if unsure)	<input type="checkbox"/>
Confined Space	12	Confined Space does not have useable rungs	<input checked="" type="checkbox"/>
	13	Confined Space depth is greater than 50 feet	<input type="checkbox"/>
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
		Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	<input type="checkbox"/>
	17	Confined Space subject to surcharge during/after a rain event	<input checked="" type="checkbox"/>
	18	CO, H2S, low O2 or other toxic/flammable gases present or anticipated	<input type="checkbox"/>
19	Confined Space has active drop connections	<input type="checkbox"/>	

* Hazards found at this site (Discuss Checked items below)

	Class	Description
X	1	2-person crew. Standard procedures and equipment. No special requirements
	2	Worksite (non-traffic) with access obstacles and/or worksite hazards
	3	Traffic site requiring special scheduling, additional personnel and/or traffic control equipment, or outsourcing
	4	Confined Space Entry requiring special scheduling, additional personnel and/or safety equipment
	5	Special Operation requiring a separate safety plan. <i>Must be approved by Corporate Safety Manager</i>

* Site Specific Safety Requirements, Must Complete for any site Class 2 & Above

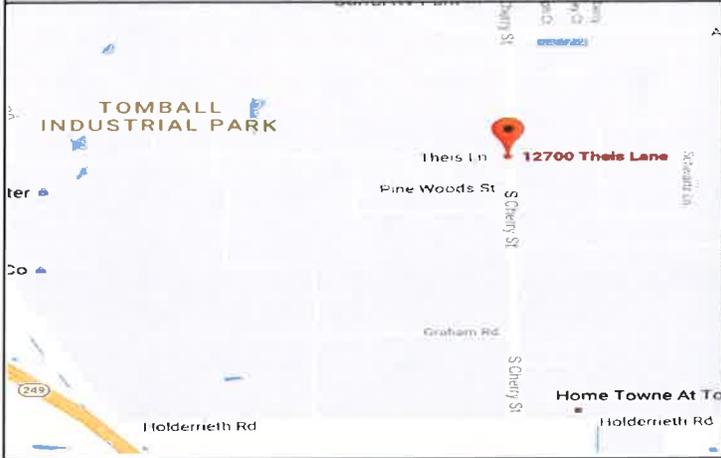
TRAFFIC CONTROL PLAN

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- This worksite does NOT require a traffic control plan
 Standard Traffic Control Plan to be used at this worksite
 This site requires a special Traffic Control Plan which is attached

Approved Field Mgr Name: Dennis McPhearson Signature: <i>Dennis McPhearson</i> Date: 9-Nov-16	Reviewed Project Mgr Name: Chuck Franklin Signature: _____ Date: _____
------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------

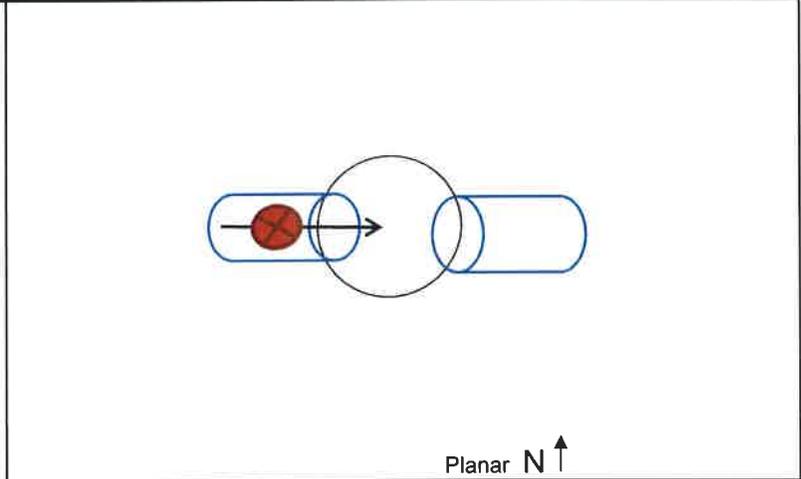
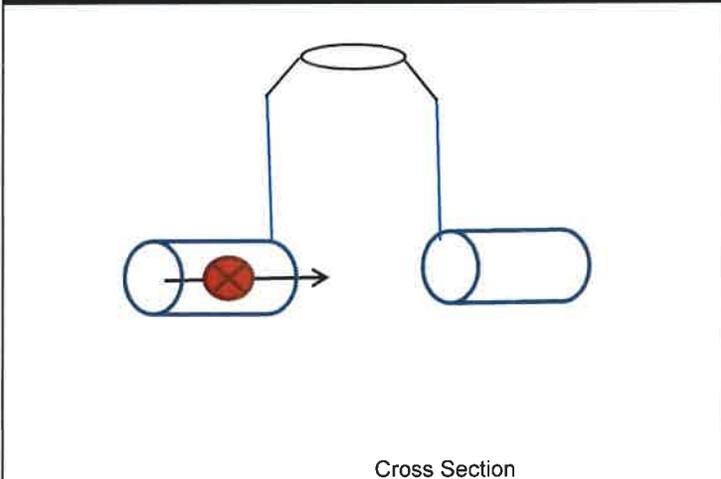
Project Name: TOMBALL		City/State: TOMBALL, TX		FM Initials: DM	
Site Name: S-04		Monitor Series:		Monitor S/N#:	
Address / Location: 12700-13048 THEIS LN.		Manhole #:		Map Page #:	
Access:	Drive	Type of System:	Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Combined <input type="checkbox"/>
			Pipe Height:	17.5	
			Pipe Width:	17.5	
			Phone Number:		



Manhole Information:

Date/Time of Investigation:	11/9/16 1240	Manhole Depth:	9.5	Feet
Site Hydraulics:	GOOD	Manhole Material / Condition:	Concrete	
Upstream Input: (L/S, P/S)	STRAIGHT OK	Pipe Material / Condition:	PVC	Fair
Upstream Manhole:	DNI	Mini System Character:	Residential <input checked="" type="checkbox"/>	Commercial <input type="checkbox"/>
Downstream Manhole:	JCT 21" LINE	Industrial <input type="checkbox"/>	Other <input type="checkbox"/>	
		Telephone Information: N/A		
Depth of Flow (Wet Dof):	5 +/- 0.25	Access Pole #:	N/A	
Range (Air Dof):	+/-	Distance From Manhole:	N/A	Feet
Peak Velocity:	1.8 fps	Road Cut Length:	N/A	Feet
Silt:	0 Inches	Trenche Length:	N/A	Feet

Other Information:



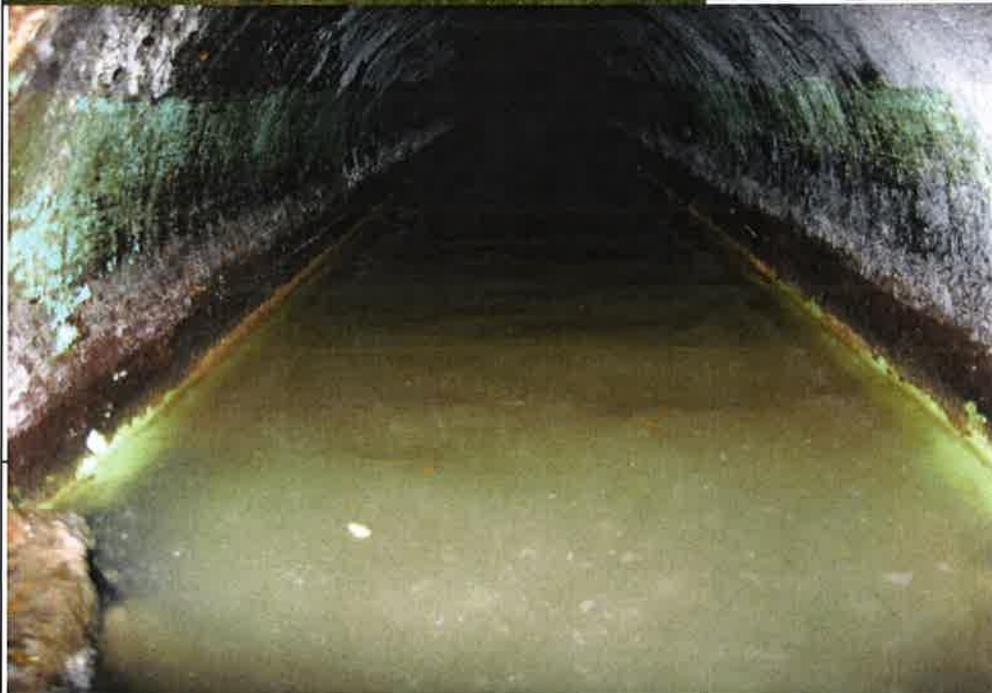
Installation Information		Backup	Yes		Distance
Installation Type:	Rino Crank	Trunk		X	500 FT
Sensors / Devices:	CS4	Lift/Pump Station		X	
Surcharge Height:	Feet	WWTP		X	
Rain Gauge Zone:		Other		X	

Additional Site Information / Comments:

GPS: N30°0773 W-95°.6129

Project Name: TOMBALL
Project Number: 25288.11

Site Name: TOMBAL, TX S-04





ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: **TOMBALL** Site ID: **S-04** Site Classification(see below) **1**

* Hazards found at this site (Discuss Checked items below)

Type	#	Specific Hazard	
Communic	1	The site is in a communications "Dead-Zone"	<input type="checkbox"/>
	2	The site is located in or adjacent to an intersection	<input type="checkbox"/>
Traffic	3	The site is located on a hill, curve, or where motorists visibility of the site or other vehicles is reduced	<input type="checkbox"/>
	4	The site is located in a high speed (>45 MPH) or high density roadway	<input type="checkbox"/>
	5	Site traffic is congested at peak hours	<input type="checkbox"/>
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	<input type="checkbox"/>
Worksite	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	<input type="checkbox"/>
	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	<input type="checkbox"/>
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	<input type="checkbox"/>
	10	Work may be performed during darkness; requiring additional site lighting	<input checked="" type="checkbox"/>
Confined Space	11	Sie is located in a high crime area (check with client & local authorities if unsure)	<input type="checkbox"/>
	12	Confined Space does not have useable rungs	<input checked="" type="checkbox"/>
	13	Confined Space depth is greater than 50 feet	<input type="checkbox"/>
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	15	Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	16	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	<input type="checkbox"/>
	17	Confined Space subject to surcharge during/after a rain event	<input checked="" type="checkbox"/>
	18	CO, H2S, low O2 or other toxic/flammable gases present or anticipated	<input checked="" type="checkbox"/>
	19	Confined Space has active drop connections	<input type="checkbox"/>

* Hazards found at this site (Discuss Checked items below)

	Class	Description
X	1	2-person crew. Standard procedures and equipment. No special requirements
	2	Worksite (non-traffic) with access obstacles and or worksite hazards
	3	Traffic site requiring special scheduling, additional personnel and/or traffic control equipment, or outsourcing
	4	Confined Space Entry requiring special scheduling, additional personnel and/or safety equipment
	5	Special Operation requiring a separate safety plan. <i>Must be approved by Corporate Safety Manager</i>

* Site Specific Safety Requirements, Must Complete for any site Class 2 & Above

TRAFFIC CONTROL PLAN

Note: All worksites located in a roadway or immediately adjacent to a roadway where the operation may impede the normal flow of traffic are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

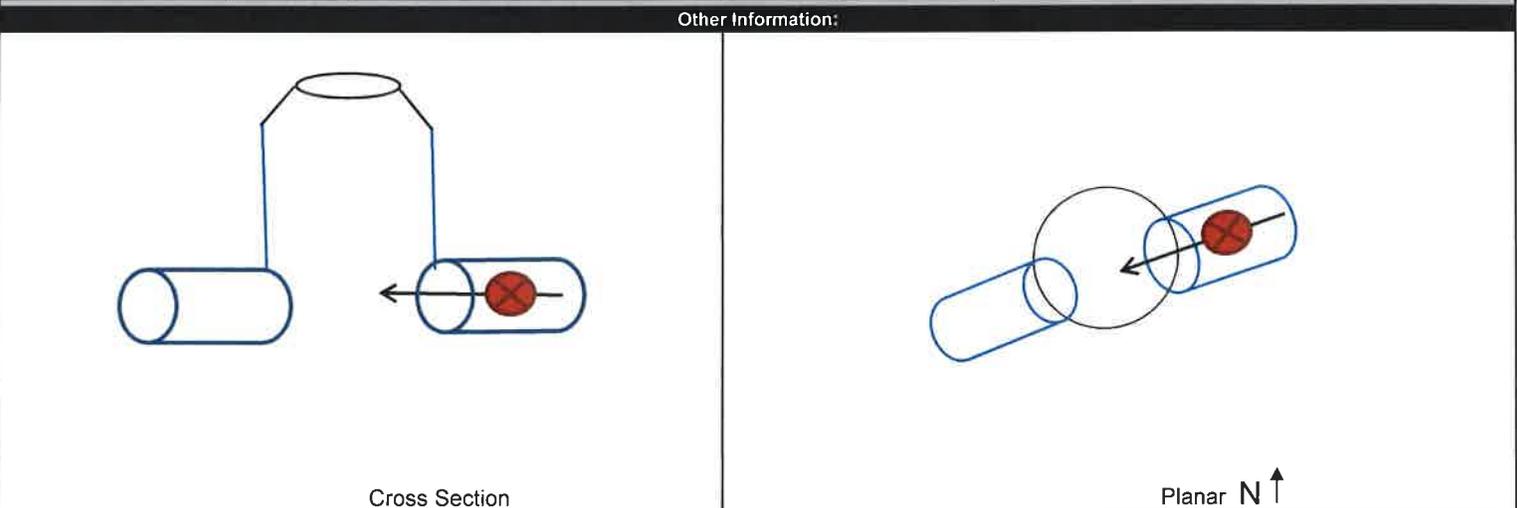
This worksite does NOT require a traffic control plan
 Standard Traffic Control Plan to be used at this worksite
 This site requires a special Traffic Control Plan which is attached

Approved Field Mgr Name: Dennis McPhearson Signature: <i>Dennis McPhearson</i> Date: 9-Nov-15	Reviewed Project Mgr Name: Chuck Franklin Signature: _____ Date: _____
------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------

Project Name: TOMBALL		City/State: TOMBALL, TX		FM Initials: DM	
Site Name: S-05		Monitor Series:		Monitor S/N#:	
Address / Location: 15111-15121 FM 2920 RD.				Manhole #:	
				Map Page #:	
Access: DRIVE WHEN DRY	Type of System:	Sanitary <input checked="" type="checkbox"/>	Storm <input type="checkbox"/>	Combined <input type="checkbox"/>	Pipe Height: 17
				Pipe Width: 17	
				Phone Number:	



		Manhole Information:				
Date/Time of Investigation:	11/10/16 1350	Manhole Depth:	9.5	Feet		
Site Hydraulics:	GOOD	Manhole Material / Condition:	Concrete			
Upstream Input: (L/S, P/S)	INVERT DEBRIS	Pipe Material / Condition:	PVC	Fair		
Upstream Manhole:	SOME BACKUP	Mini System Character:	Residential X	Commercial	Industrial	Other
Downstream Manhole:	JCT 21" LINE	Telephone Information:	N/A			
Depth of Flow (Wet Dof):	3.25 +/- 0.25	Access Pole #:	N/A			
Range (Air Dof):	+/-	Distance From Manhole:	N/A	Feet		
Peak Velocity:	0.75 fps	Road Cut Length:	N/A	Feet		
Silt:	0 Inches	Trenche Length:	N/A	Feet		



Installation Information		Backup	Yes	Distance
Installation Type:	Rino Crank	Trunk	X	2000 FT
Sensors / Devices:	CS4	Lift/Pump Station	X	
Surcharge Height:	Feet	WWTP	X	
Rain Gauge Zone:		Other	X	

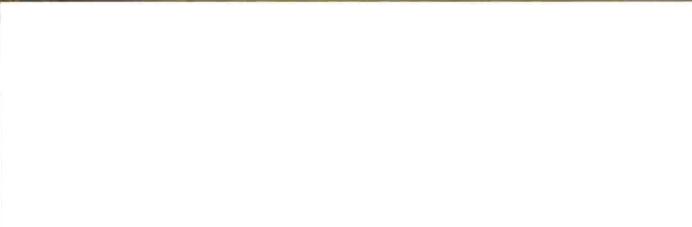
Additional Site Information / Comments:

GPS: N30°0888 W-95°.6498

Project Name: TOMBALL

Project Number: 25288.11

Site Name: TOMBAL,TX S-05





ADS Site Report

Quality Form

Flow Monitoring Site Safety Plan

Project Name: **TOMBALL** Site ID: **S-05** Site Classification(see below) **1**

* Hazards found at this site (Discuss Checked items below)

Type	#	Specific Hazard	
Communic	1	The site is in a communications "Dead-Zone"	<input type="checkbox"/>
	2	The site is located in or adjacent to an intersection	<input type="checkbox"/>
Traffic	3	The site is located on a hill, curve, or where motorists visibility of the site or other vehicles is reduced	<input type="checkbox"/>
	4	The site is located in a high speed (>45 MPH) or high density roadway	<input type="checkbox"/>
	5	Site traffic is congested at peak hours	<input type="checkbox"/>
Access	6	Site has access obstacles (rough terrain, fences, deep easement, etc.)	<input type="checkbox"/>
	7	Worksite contains hazards (terrain, slope, obstructions, etc.)	<input type="checkbox"/>
Worksite	8	Elevated work requiring a ladder / work near an unguarded edge. Raised manhole (indicate height below)	<input type="checkbox"/>
	9	Pedestrian control necessary as the site is located in or near a walkway, school, playground, etc.	<input type="checkbox"/>
	10	Work may be performed during darkness; requiring additional site lighting	<input checked="" type="checkbox"/>
	11	Sie is located in a high crime area (check with client & local authorities if unsure)	<input type="checkbox"/>
Confined Space	12	Confined Space does not have useable rungs	<input checked="" type="checkbox"/>
	13	Confined Space depth is greater than 50 feet	<input type="checkbox"/>
	14	Confined Space has internal platforms, weirs or other obstructions that interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
		Work requires lateral movement that would interfere with or prevent unobstructed vertical retrieval	<input type="checkbox"/>
	15	Flow is hazardous due to depth, velocity, pipe diameter, or is industrial process flow	<input type="checkbox"/>
	16	Confined Space subject to surcharge during/after a rain event	<input checked="" type="checkbox"/>
	17	CO, H2S, low O2 or other toxic/flammable gases present or anticipated	<input type="checkbox"/>
18	Confined Space has active drop connections	<input type="checkbox"/>	

* Hazards found at this site (Discuss Checked items below)

	Class	Description
X	1	2-person crew. Standard procedures and equipment. No special requirements
	2	Worksite (non-traffic) with access obstacles and or worksite hazards
	3	Traffic site requiring special scheduling, additional personnel and/or traffic control equipment, or outsourcing
	4	Confined Space Entry requiring special scheduling, additional personnel and/or safety equipment
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* Site Specific Safety Requirements, Must Complete for any site Class 2 & Above

TRAFFIC CONTROL PLAN

Note: All worksites located in a roadway or immediately adjacent to a roadway where the operation may impede the normal flow of traffic are required to have a Traffic Control Plan. Standard Traffic Control Plans are to be carried in the vehicle and referred to when setting up the worksite. Special Traffic Control Plans are to be developed when required by clients or regulating agencies or when a standard Traffic Control Plan is not sufficient to control traffic at the worksite.

- This worksite does NOT require a traffic control plan
 Standard Traffic Control Plan to be used at this worksite
 This site requires a special Traffic Control Plan which is attached

Approved Field Mgr Name: Dennis McPhearson Signature: <i>Dennis McPhearson</i> Date: 9-Nov-15	Reviewed Project Mgr Name: Chuck Franklin Signature: _____ Date: _____
------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------

RESCUE TEAM – RESCUE SERVICE FORM

This form is to be completed by project staff and signed by the Project Supervisor prior to the commencement of any field work. Completed forms are to be sent to the Corporate Safety Office and maintained with the Project files.

This Safety form helps ensure that development and implementation of procedures to summon rescue and emergency services, for rescuing entrants from permit spaces, for providing necessary emergency services to rescued employees, and for preventing unauthorized personnel from attempting rescue are met.

Project Name: TOMBALL	JOB #: 25288.11	Start Date: 11/08/16
Rescue Team: TOMBALL, TX	ADS Supervisor: DENNIS McPHEARSON	

FIRE STATION #5 RESPONDERS ASS. CHIEF FONTEOT 281-351-7127

RESCUE TEAM - RESCUE SERVICE TOPIC	<input checked="" type="checkbox"/>
Have team members of the service been trained as permit space entrants, at a minimum, including training in the potential hazards of all permit spaces, or of representative permit spaces, from which rescue may be needed? Can team members recognize the signs, symptoms, and consequences of exposure to any hazardous atmospheres that may be present in those permit spaces?	<input checked="" type="checkbox"/>
Are team members provided with, and properly trained in, the use and need for PPE, such as SCBA or fall arrest equipment, which may be required to perform permit space rescues? Are team members properly trained to perform his or her functions and make rescues, and to use any rescue equipment, such as ropes and backboards, that may be needed in a rescue attempt?	<input checked="" type="checkbox"/>
Are team members trained in the first aid and medical skills needed to treat victims overcome or injured by the types of hazards that may be encountered in the permit spaces?	<input checked="" type="checkbox"/>
Do team members perform their functions safely and efficiently? Do rescue team personnel focus on their own safety before considering the safety of the victim?	<input checked="" type="checkbox"/>
If necessary, can the rescue team properly test the atmosphere to determine if it is IDLH?	<input checked="" type="checkbox"/>
Can the rescue team identify information pertinent to the rescue from entry permits, hot work permits, and MSDSs?	<input checked="" type="checkbox"/>
Has the rescue team been informed of any hazards to personnel that may arise from outside the space, such as those that may be caused by future work near the space?	<input checked="" type="checkbox"/>
If necessary, can rescue team properly retrieve victims from a permit space that has a limited size opening (less than 24 inches 960.9 cm) in diameter), limited internal space, or internal obstacles or hazards?	<input checked="" type="checkbox"/>
If necessary, can the rescue team safely perform an elevated (high angle) rescue?	<input checked="" type="checkbox"/>
Does the rescue team have a plan for each of the kinds of permit space rescue operations? Is the plan adequate for all types of rescue operations that may be needed?	<input checked="" type="checkbox"/>

I, **D. McPHEARSON** certify that I have interviewed the Rescue team – Rescue Service on the above topics and that I understand their ability to handle the rescue requirements of the work to be performed. A copy of this completed form has been supplied to the Rescue Team – Rescue Service and a copy submitted to corporate safety management and maintained with the project files.



Employee's Signature

Date

11/8/2016



Supervisor's Signature

Appendix B – Flow Monitor Equipment Specifications

FLOWSHARK[®] TRITON

The new FlowShark[®] Triton from ADS is a “Fit-for-Purpose” open channel flow monitor for use in sanitary, combined, and storm sewers. It is designed to be the most adaptable and versatile flow monitoring device available for collection systems. It is a single pipe or dual pipe flow measurement system and is certified to the highest level of Intrinsic Safety.

FlowShark TRITON

This multiple technology flow monitor will power almost every available sensor technology that is used in wastewater applications today. It offers unparalleled versatility and redundancy and is also the lowest priced monitor on the market. The four multiple technology sensor options available in the FlowShark Triton include: a Peak Combo Sensor; Slimline Peak Combo Sensor; Surface Combo Sensor; and a Quadredundant Ultrasonic Sensor (see back for technology and specifications). This array of monitoring technologies provides a fit-for-purpose monitoring platform.

The FlowShark Triton is also adaptable to a wide range of customer applications and budgets. It can be configured as an economical single sensor monitor or a dual sensor monitor. It offers a longer battery life and fewer parts for a more reliable system. This provides a lower purchase price and a lower lifetime ownership cost. The FlowShark Triton provides the lowest power cost per data sample of any Intrinsically Safe flow monitor available.



About ADS

A leading technology and service provider, ADS Environmental Services[®] has established the industry standard for open channel flow monitoring and has the only ETV-verified flow monitoring technology for wastewater collection systems. These battery-powered monitors are specially designed to operate with reliability, durability, and accuracy in sewer environments.

FlowShark TRITON Features

- Versatile and adaptable multiple technology sensors
- Two sensor ports supporting three interchangeable sensors providing up to six sensor measurements at a time
- Supports single or dual pipe monitoring
- Wireless, land-line, or serial communication for field versatility
- Industry leading battery life with a GSM/GPRS wireless connection providing up to 15-months at the standard 15-minute sample rate (varies with sensor configuration)
- External power option available with an ADS External Modem Unit (EMU) or External Multiplexer (EMUX) and 12-volt DC power supply
- Data available using Modbus protocol via wireless or serial connection
- Monitor-Level Intelligence (MLI[®]) improves accuracy and allows the FlowShark Triton to operate in a wide range of hydraulic conditions
- Superior noise reduction design for maximizing acoustic signal detection from depth and velocity sensors
- Four reporting software packages for accessing flow information including: Profile[®] collection and reporting software; IntelliServe[®] web-based alarming, Sliicer.com[®] for I/I analysis, and FlowView Portal[®] for online access to flow data
- Intrinsically-Safe (IS) standard - certification by IECEx for use in Zone 0/Class I, Div. 1, Groups C & D, and ATEX Zone 0
- Thick, seamless, high-impact, ABS plastic canister with aluminum end cap - meets IP68 standard
- Electronics are protected eliminating exposure of circuits when opening the canister or changing the battery

ADS ENVIRONMENTAL SERVICES[®]

A Division of ADS LLC

The FlowShark Triton features three depths and two velocities with four sensor options. Each sensor provides multiple technologies for continuous running of comparisons.

Peak Combo Sensor

(Design Specifications)

Dimensions: 6.63"(l) x 1.5"(w) x 1.0"(h)

This versatile and economical sensor includes three measurement technologies in a single housing: The ADS patented continuous wave peak velocity, an uplooking ultrasonic depth, and a pressure depth.

Continuous Wave Velocity

Range: -30 ft/sec to +30 ft/sec

Operating Range: 1.5 inches - 5 feet

Resolution: 0.01 ft/sec

Accuracy: +/- 0.2 ft/sec or 4% of actual peak velocity (whichever is greater) in flow velocities between -5 and 20 ft/sec

Uplooking Ultrasonic Depth

Performs with rotation of up to 30 degrees from the horizontal axis of the invert

Operating Range: 1.5 inches - 5 feet

Resolution: 0.01"

Accuracy: The greater of 0.5% of reading or 0.125"

Pressure Depth

Range: 0-5 PSI (11.5') or 0-15 PSI (34.5')

Accuracy: +/- 1.0% of full scale

Resolution: 0.01"

Slimline Peak Combo Sensor

(Design Specifications)

Dimensions: 5.36"(l) x 1.25"(w) x 0.81"(h)

A continuous wave velocity sensor with uplooking ultrasonic depth designed specifically for measuring shallow flows.

Continuous Wave Velocity

Range: -30 ft/sec to +30 ft/sec

Operating Range: 1.0 inches - 5 feet

Resolution: 0.01 ft/sec

Accuracy: +/- 0.2 ft/sec or 4% of actual peak velocity (whichever is greater) in flow velocities between -5 and 20 ft/sec

Uplooking Ultrasonic Depth

Performs with rotation of up to 30 degrees from the horizontal axis of the invert

Operating Range: 1.0 inches - 5 feet

Resolution: 0.01"

Accuracy: The greater of 0.5% of reading or 0.125"

Quadredundant Ultrasonic Level Sensor

(Tested Specifications)

Dimensions: 7.45"(l) x 4.13"(w) x 0.86"(h)

This non-intrusive, zero-drift sensing method results in a stable, accurate, and reliable flow depth calculation. Four independent ultrasonic transducers allow for independent cross-checking.

Quadredundant Ultrasonic Depth

(Does not require electronic offsets)

Minimum dead band: 0.5" from the face of the sensor or 5% of the maximum range; whichever is greater

Maximum operating air range: 10 feet

Resolution: 0.01"

Accuracy: +/- 0.125" with 0.0" drift
Compensated for variations in air temperature

Surface Combo Sensor

(Design Specifications)

Dimensions: 9.56"(l) x 4.19"(w) x 2.26"(h)

This revolutionary new sensor features four technologies including surface velocity, quadredundant ultrasonic depth, surcharge continuous wave velocity, and pressure depth.

Surface Velocity *

Minimum air range of 3" from crown of pipe

Maximum air range of 48"

Range: 0.75 to 15 ft/sec

Resolution: 0.01 ft/sec

Accuracy: +/-0.25 ft/sec or 5% of actual reading (whichever is greater) in flow velocities between 0.75 and 15 ft/sec

Quadredundant Ultrasonic Depth

(See **Quadredundant Ultrasonic Depth Specifications** Above)

Surcharge Continuous Wave Velocity

(Under submerged conditions provides the same accuracy and range as **Continuous Wave Velocity** for Peak Combo)

Pressure Depth

(Under submerged conditions provides the same accuracy and range as **Pressure Depth** for Peak Combo)

Product Specifications

Connectors

U.S. Military spec. MIL-C 26482 series 1, for environmental sealing, with gold plated contacts

Communications Options

- Quad band GSM/GPRS wireless modem
- Direct connection to PC using serial communication cable
- Land-line telephone interface module
- Modbus interface via wireless or serial connection

Monitor Interfaces

Supports simultaneous interfaces with as many as two combo sensors

Power

Internal - Battery endurance with a GPRS modem and a full complement of sensors:

- Greater than 15-months at 15-minute sample rate*
- Greater than 6-months at 5-minute sample rate*

External - Optional external power available with ADS External Modem Unit (EMU), External Multiplexer (EMUX), and ADS or customer provided 12-volt DC power supply

* Based on one data collection call per day (varies with sensor configuration)

Intrinsic Safety Certification

- Certified under the ATEX European Intrinsic Safety standards for Zone 0 rated hazardous areas
- Certified under IECEx (International Electrotechnical Commission Explosion Proof) Intrinsic Safety standards for use in Zone 0/Class I, Div. 1, Groups C&D rated hazardous areas

Other Certifications/Compliances

- FCC Part 15 and Part 68 compliant
- Carries the EU CE mark
- ROHS (lead free) compliant
- Canada IC CS-03 compliant

Operating Temperature

-4 degrees to 104 degrees F
(-20 degrees to 40 degrees C)

ADS ENVIRONMENTAL SERVICES®

A Division of ADS LLC

ADS. An IDEX Water & Wastewater Business. **IDEX**

1300 Meridian Street, Suite 3000 - Huntsville, AL 35801

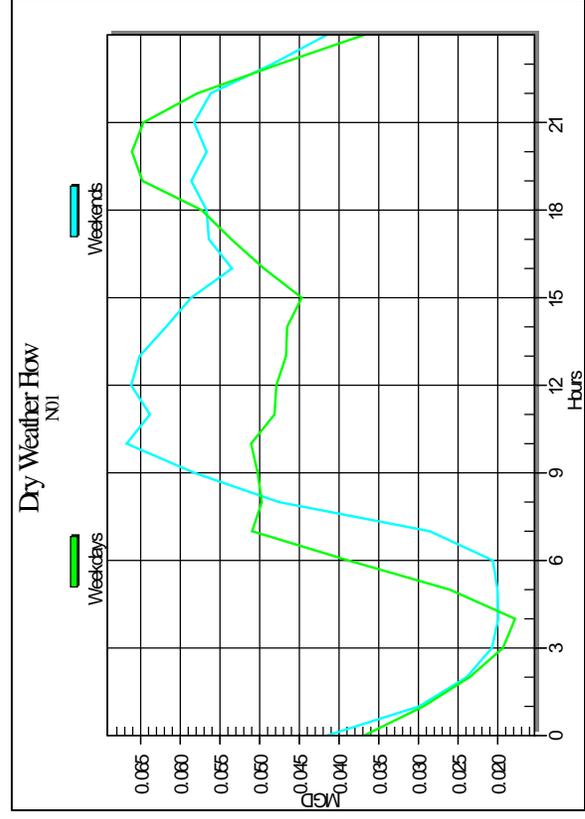
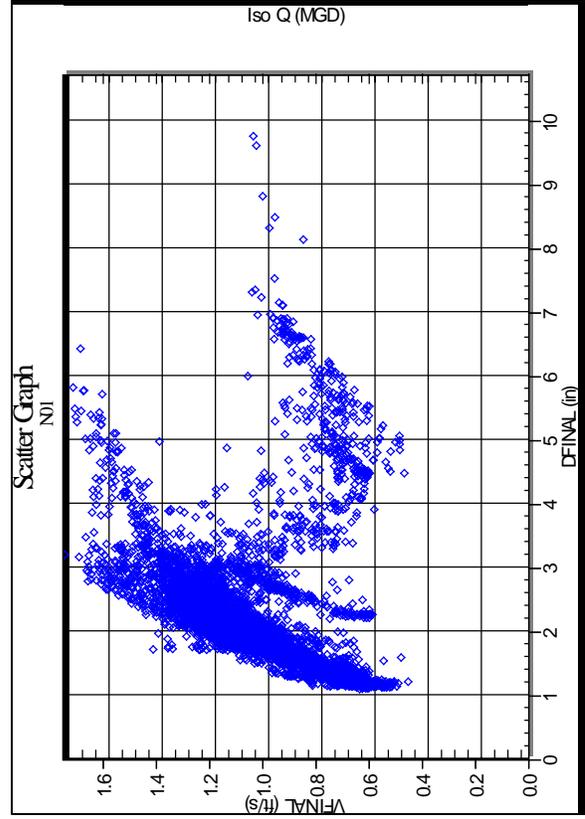
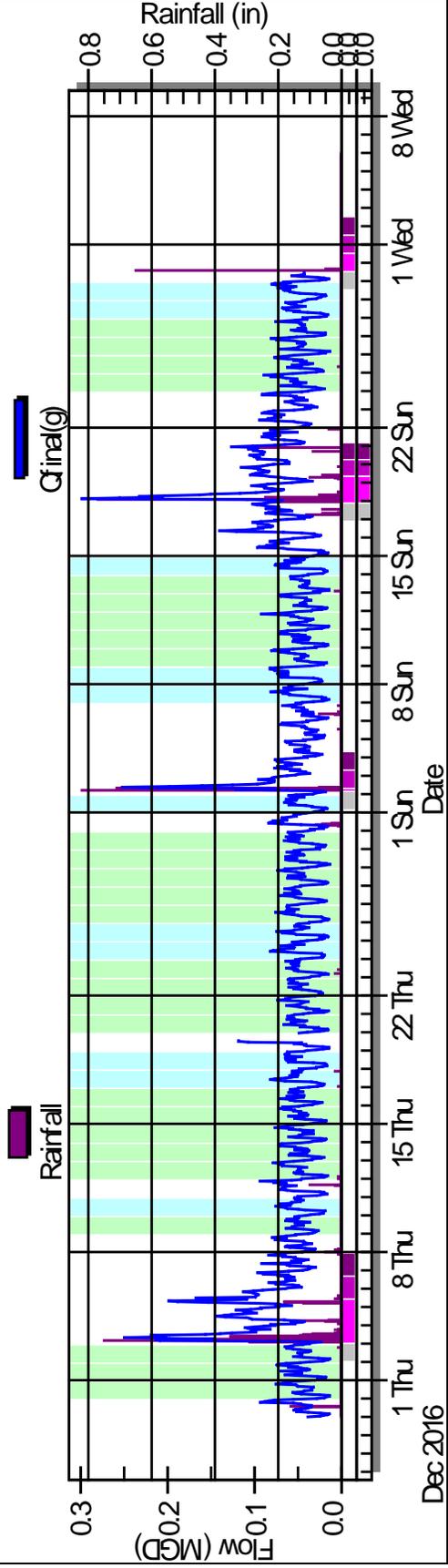
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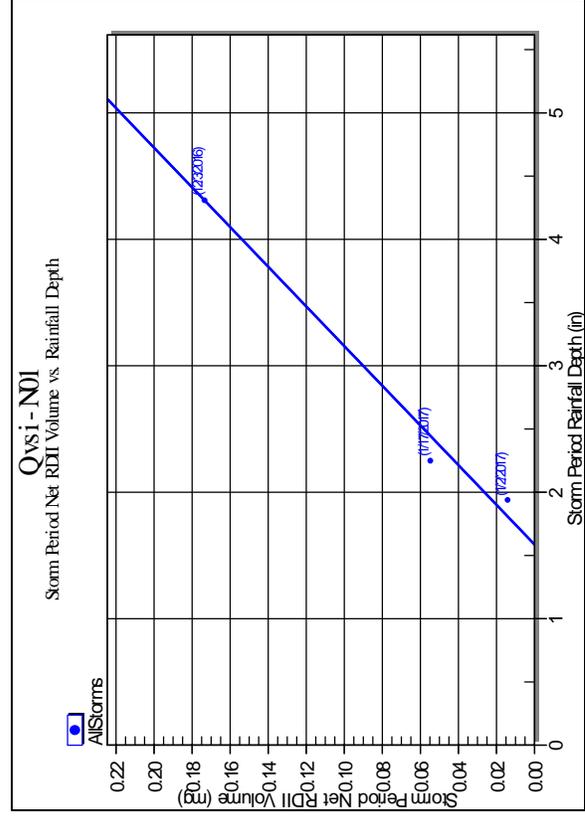
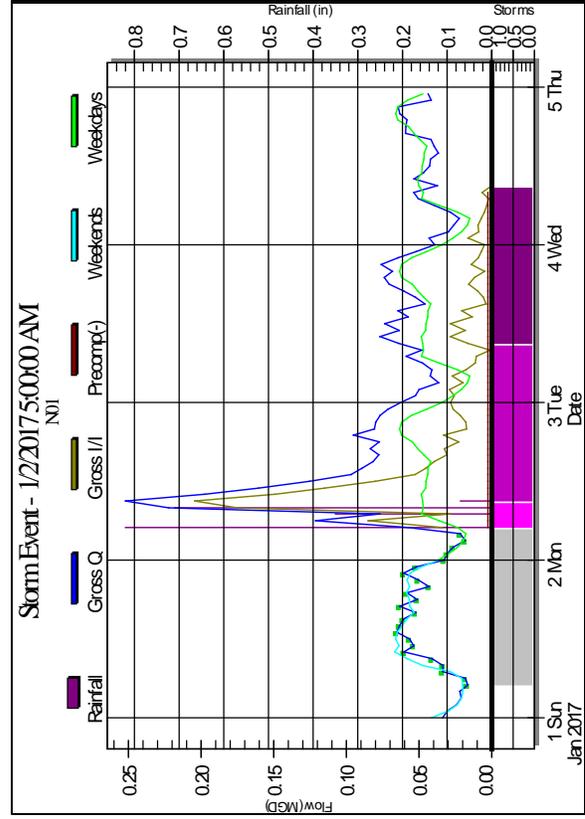
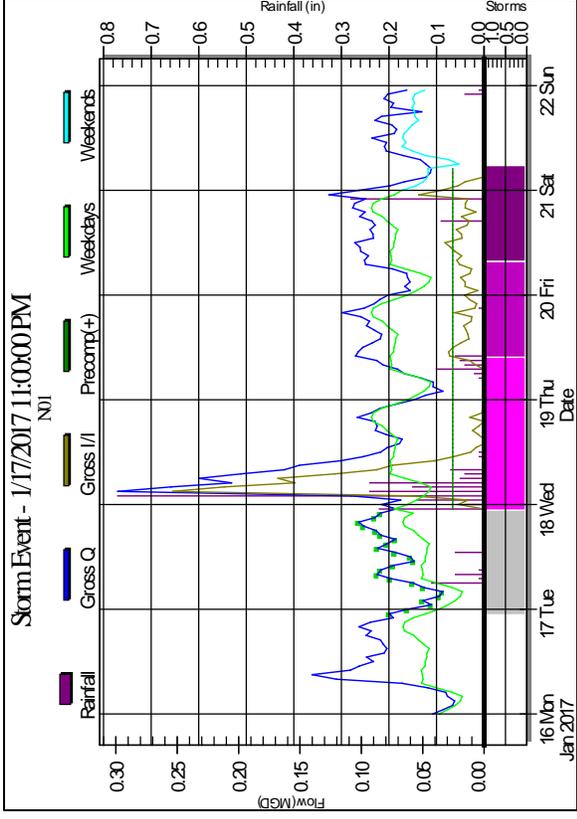
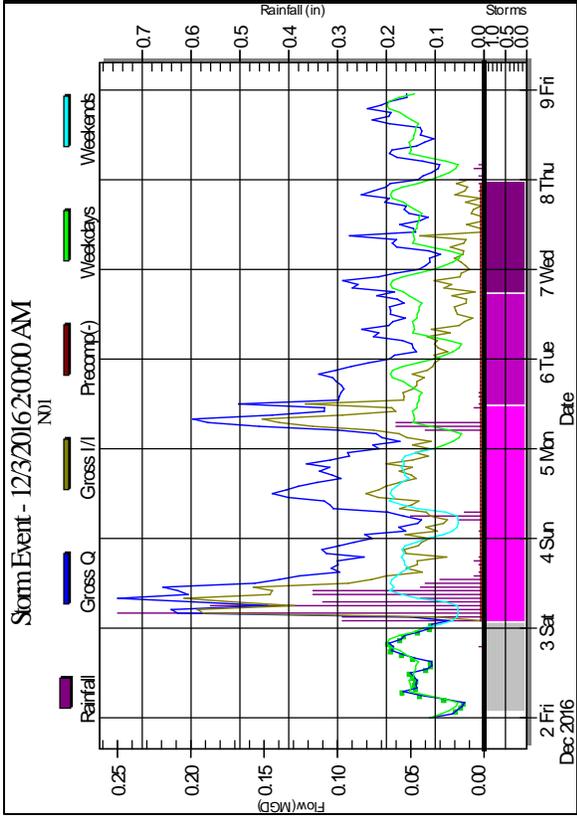
Toll Free: 1-800-633-7246

* Flow conditions in some applications may prevent the surface velocity technology from being used.

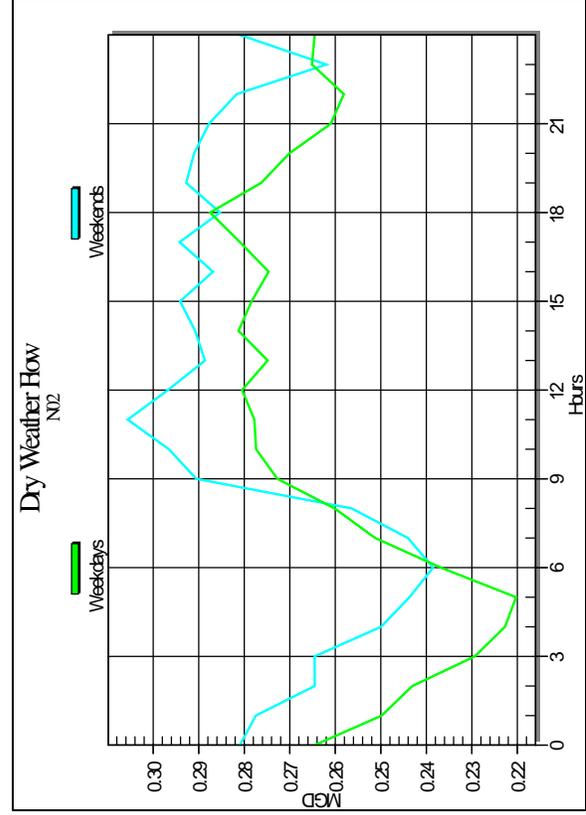
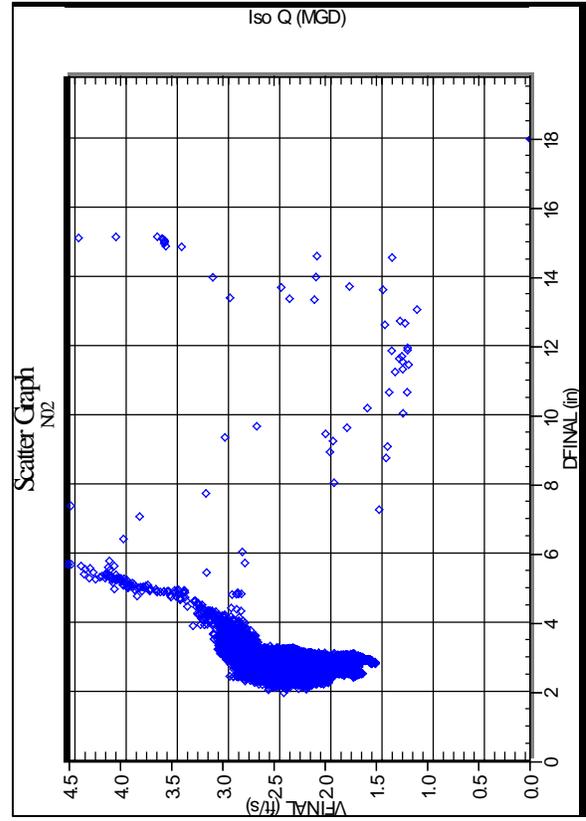
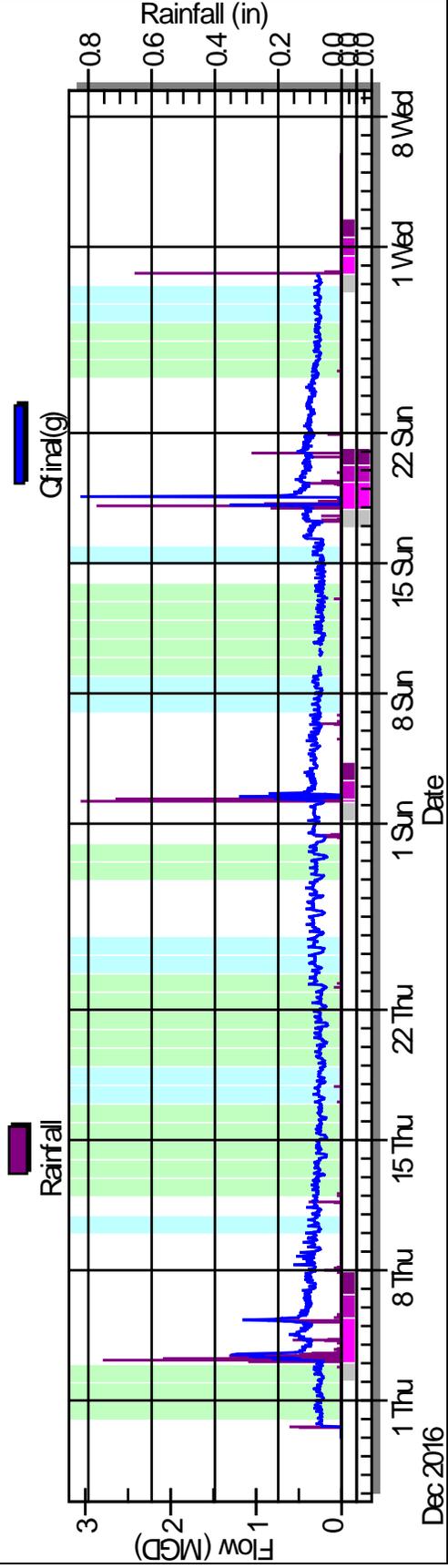
Appendix C – Flow Monitor Data

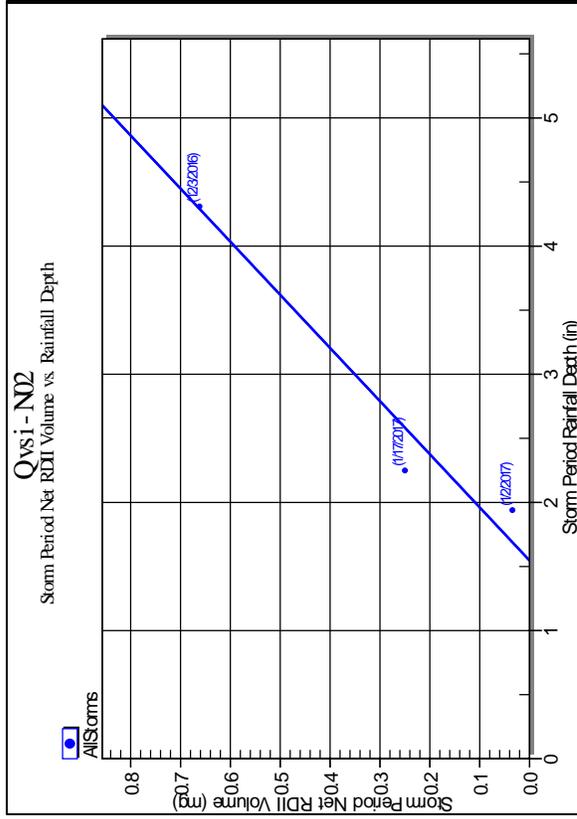
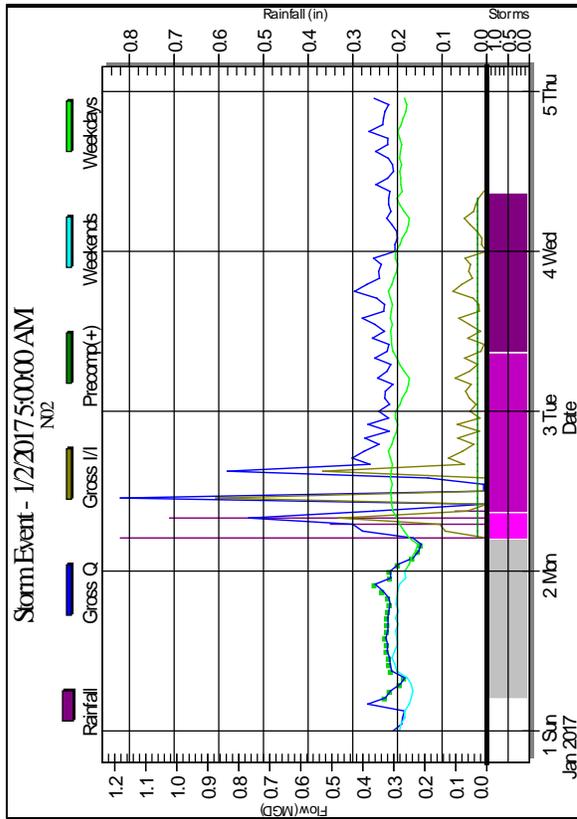
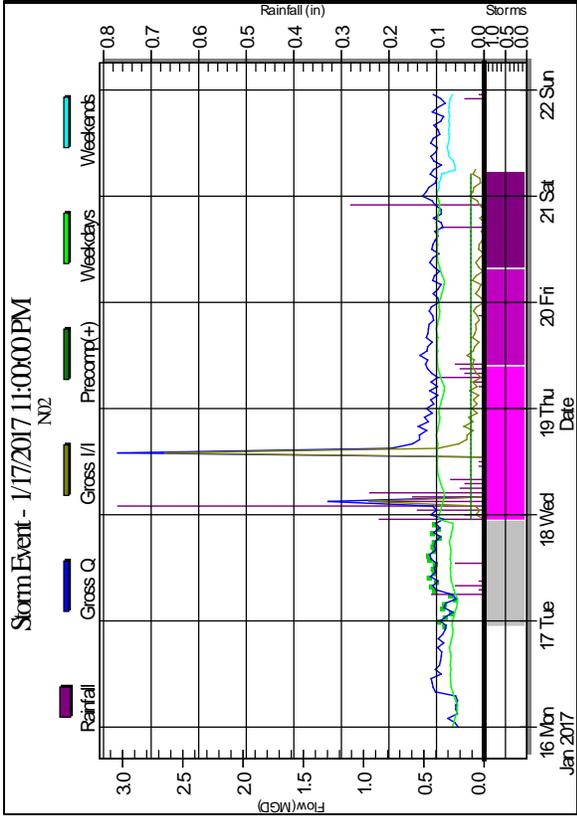
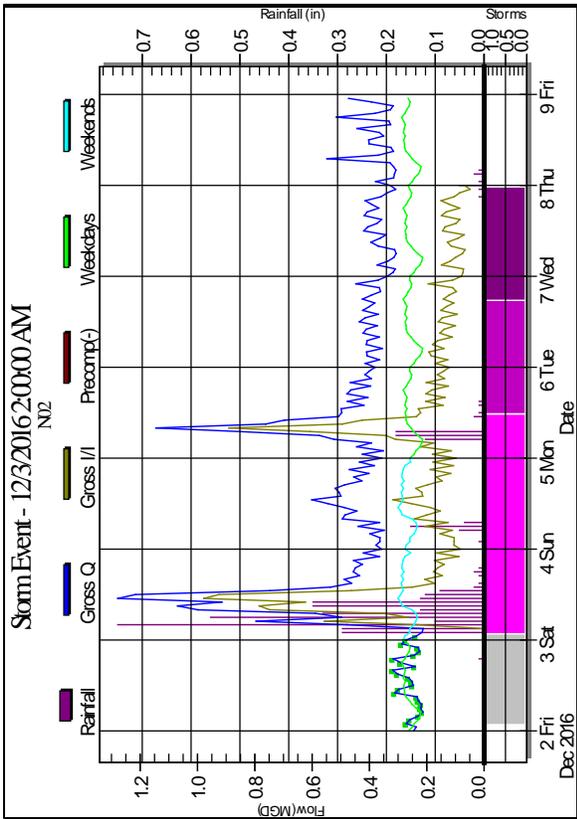
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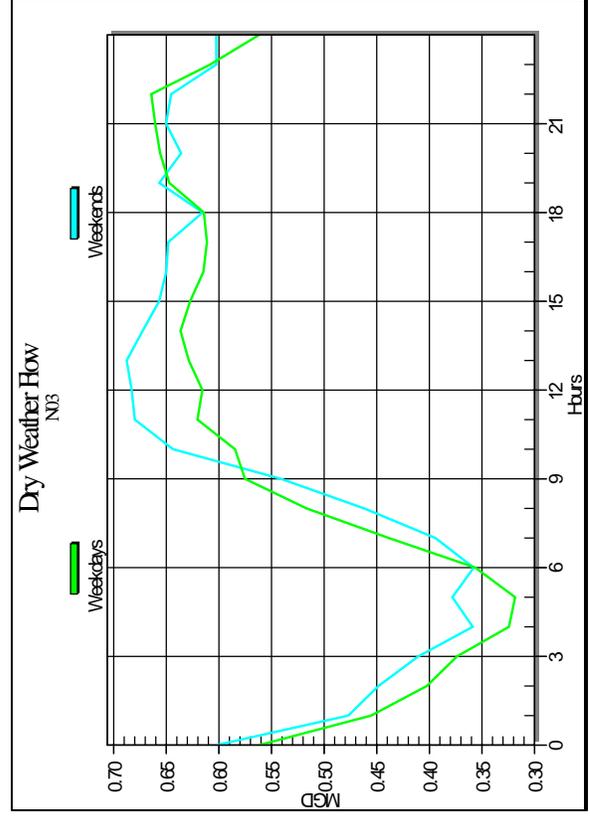
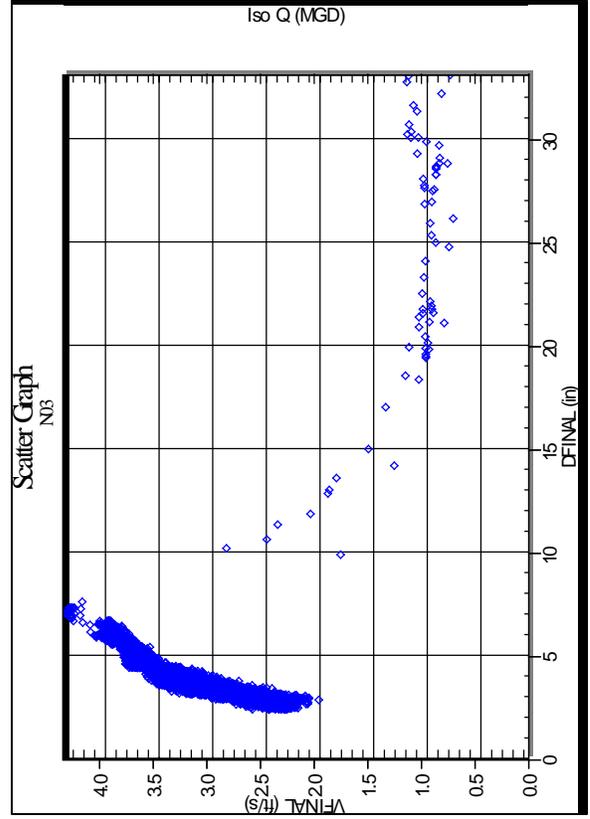
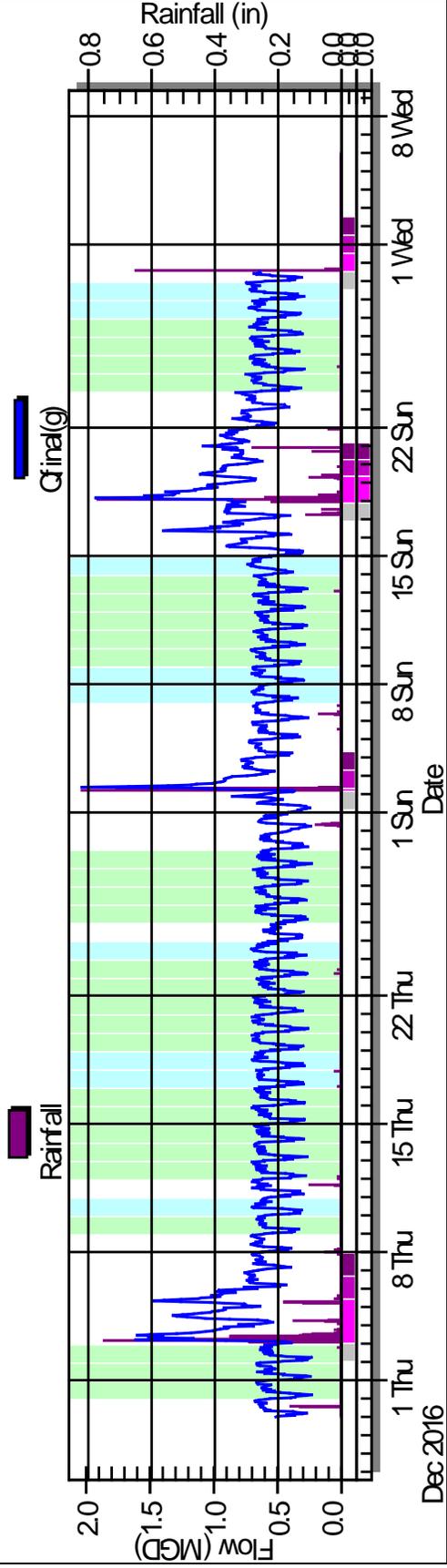


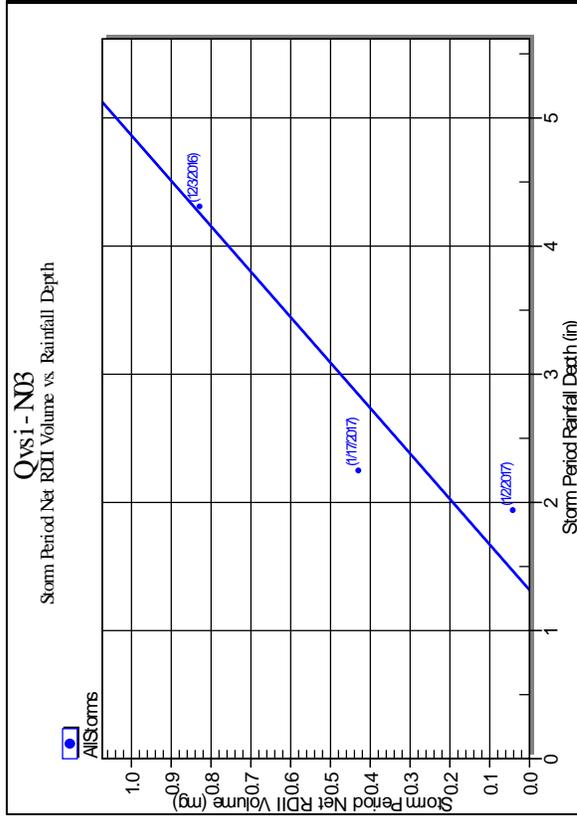
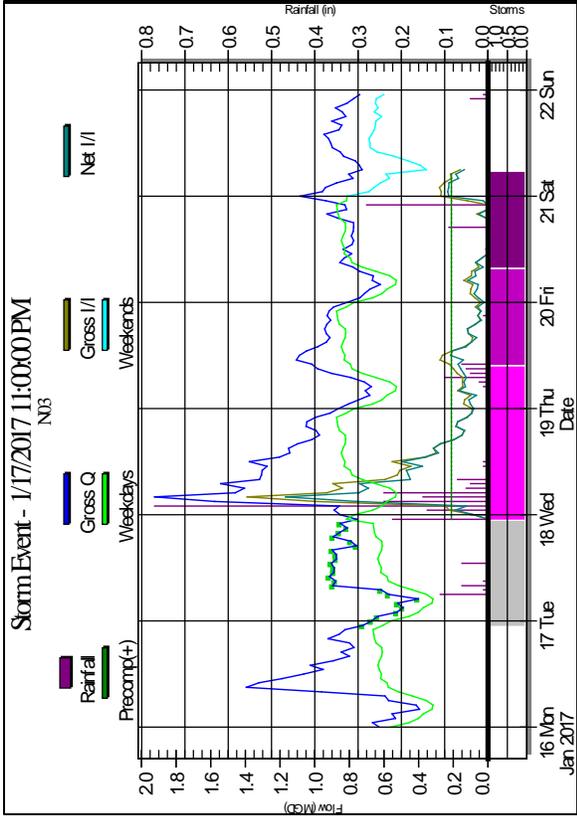
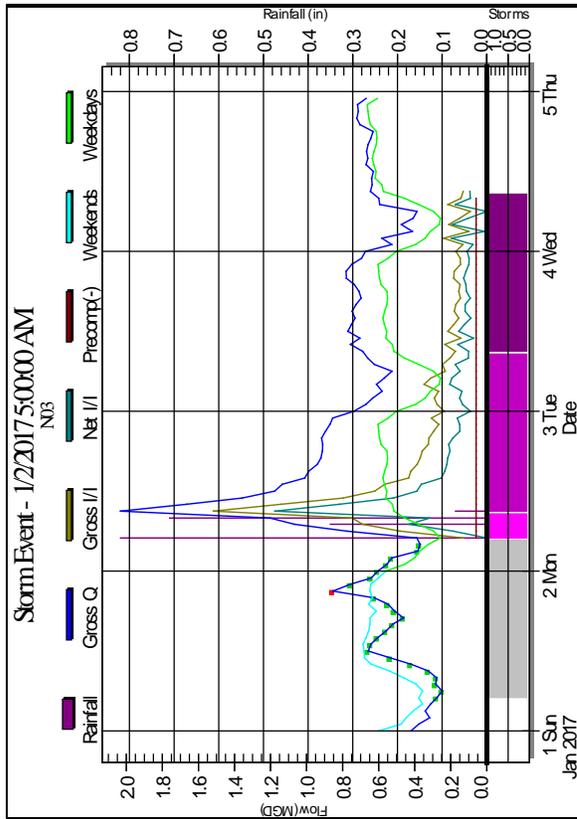
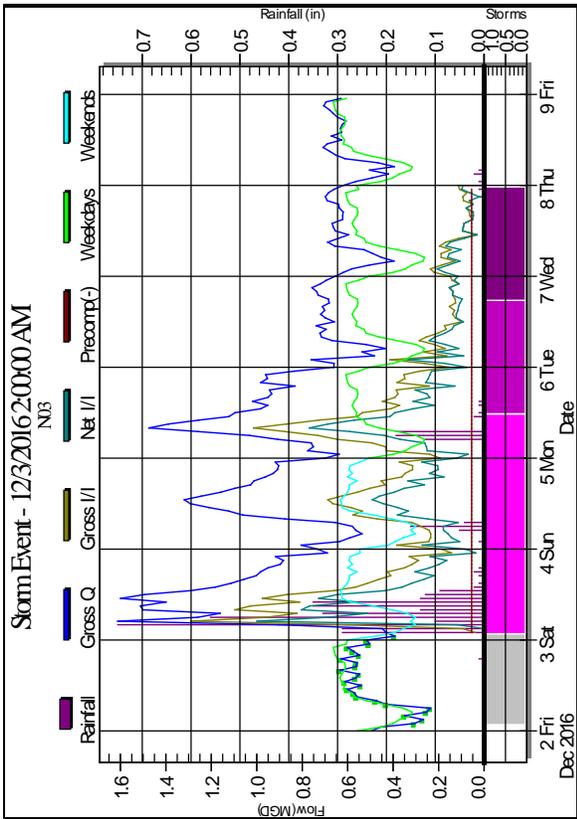
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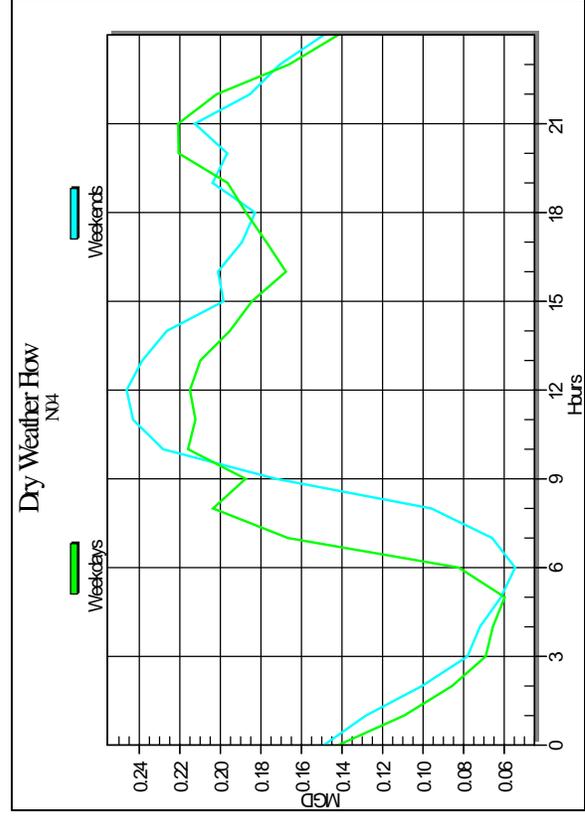
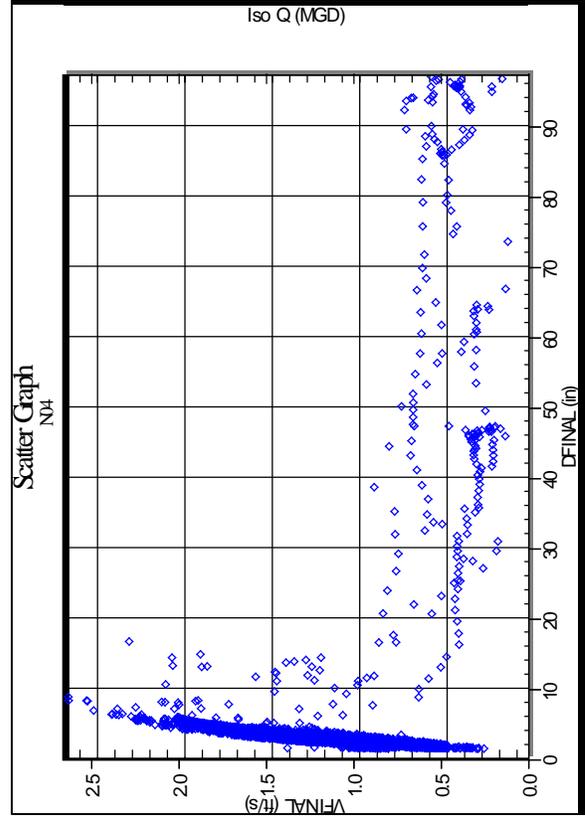
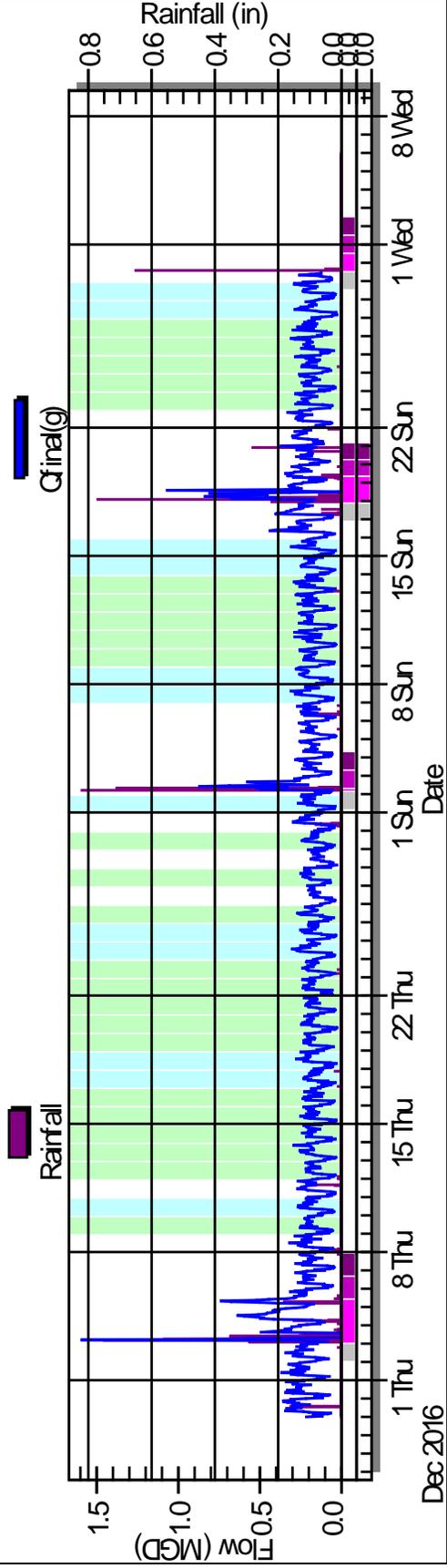


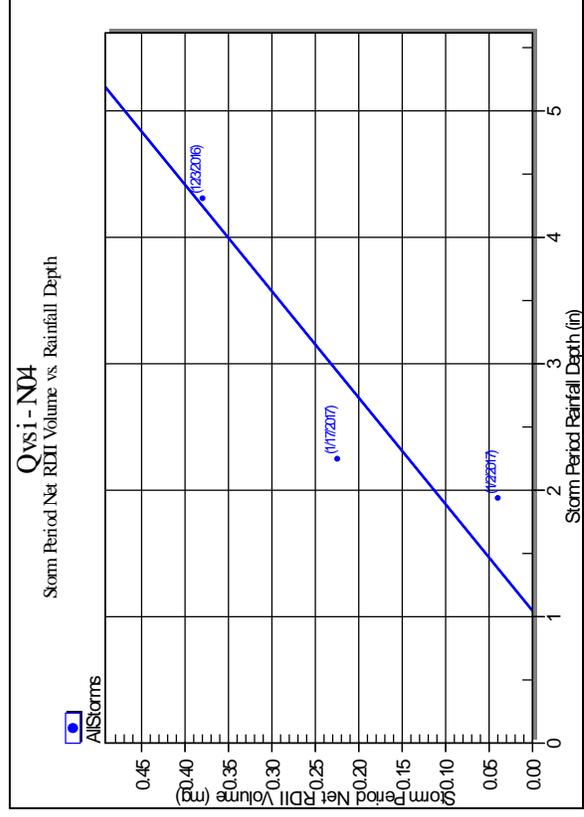
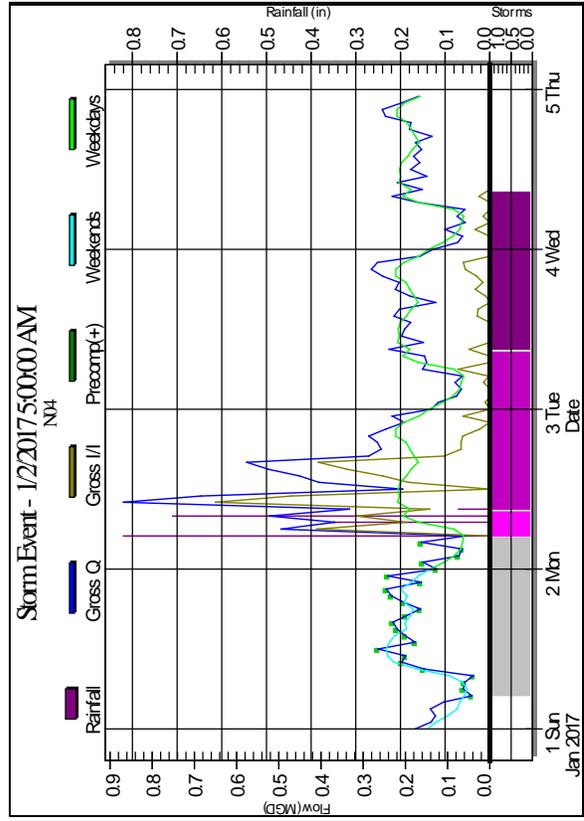
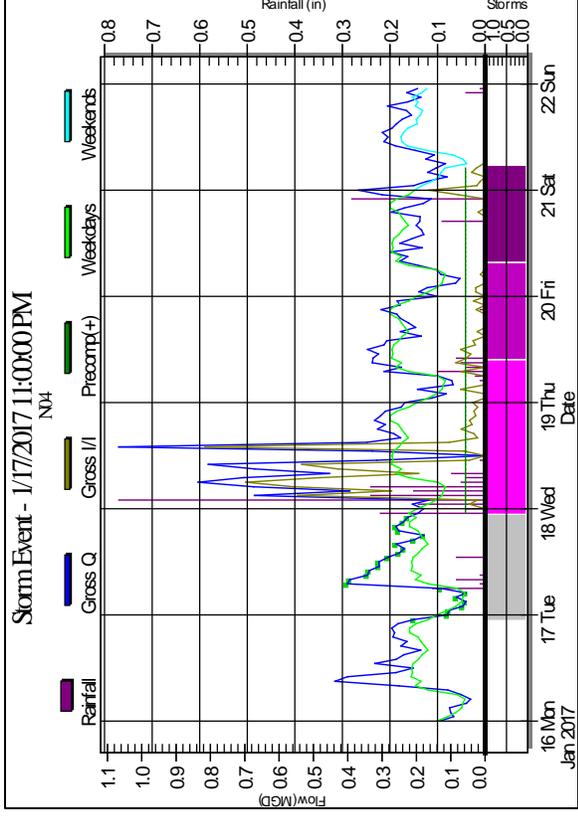
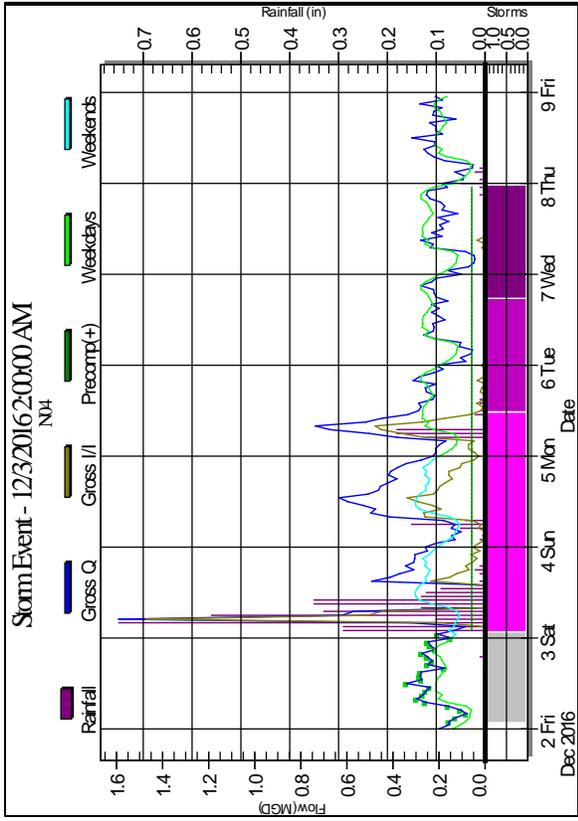
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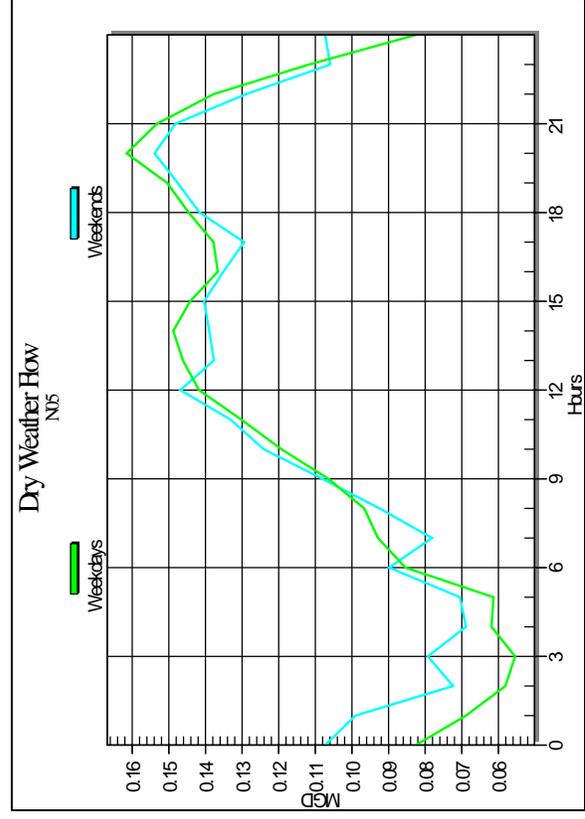
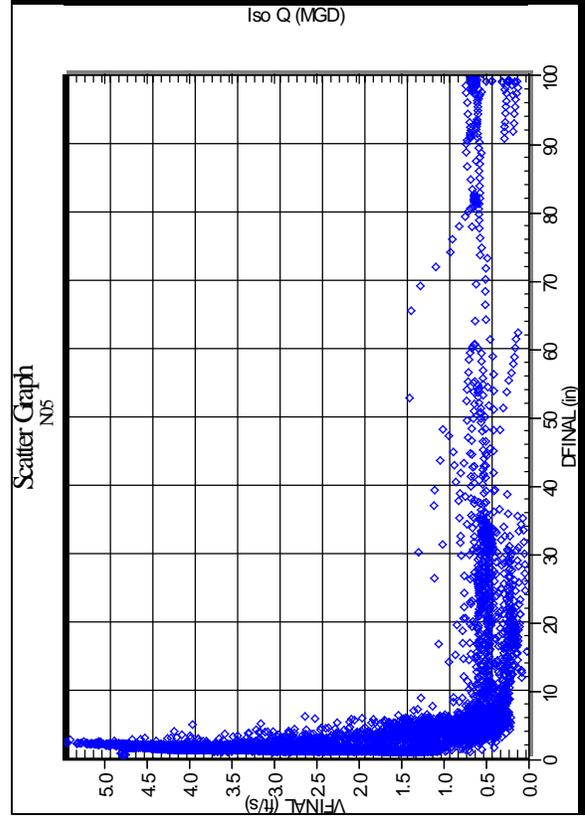
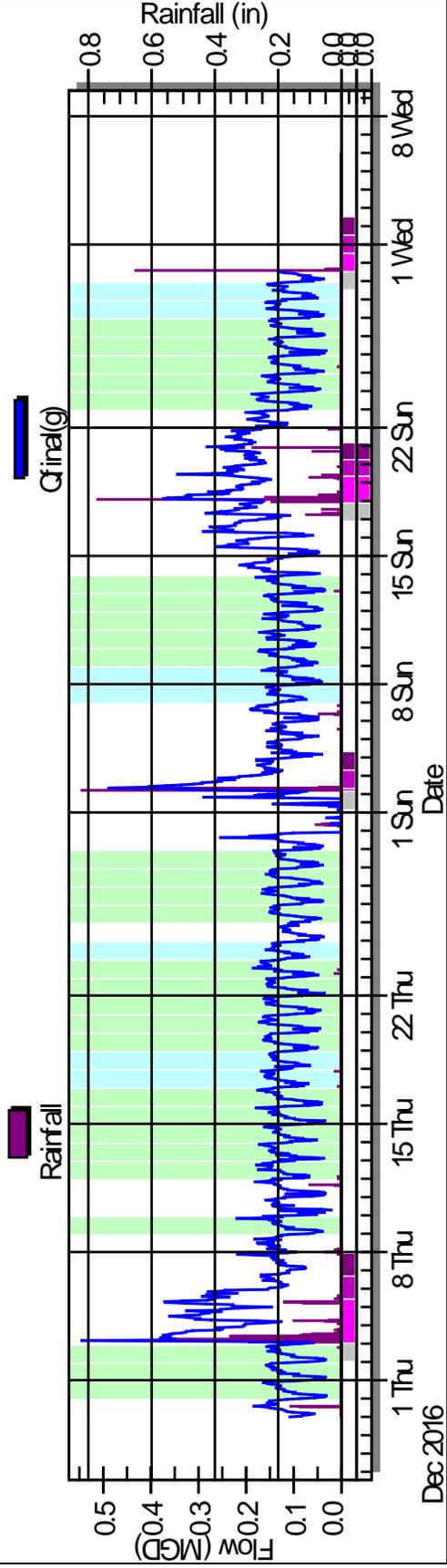


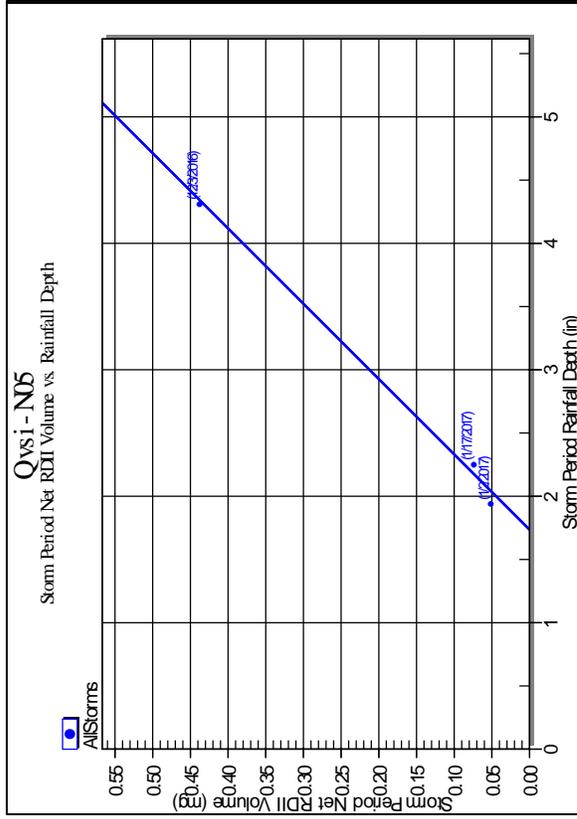
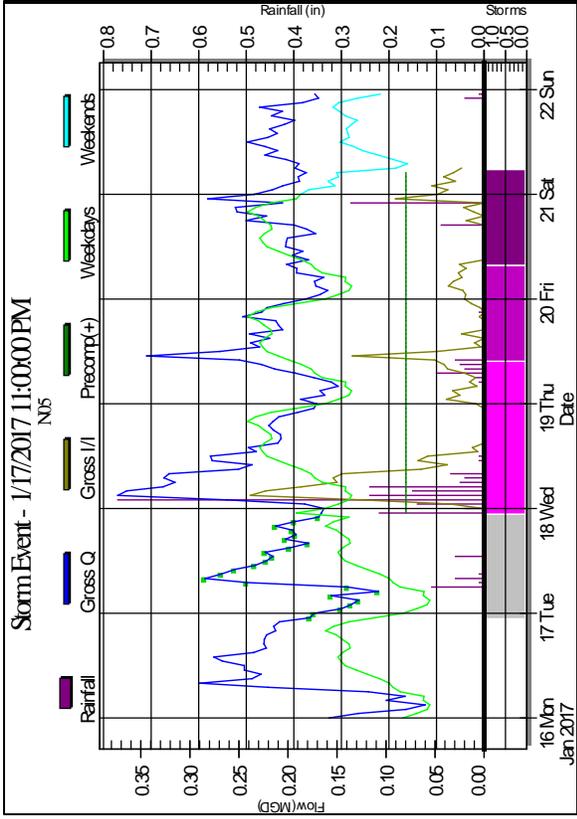
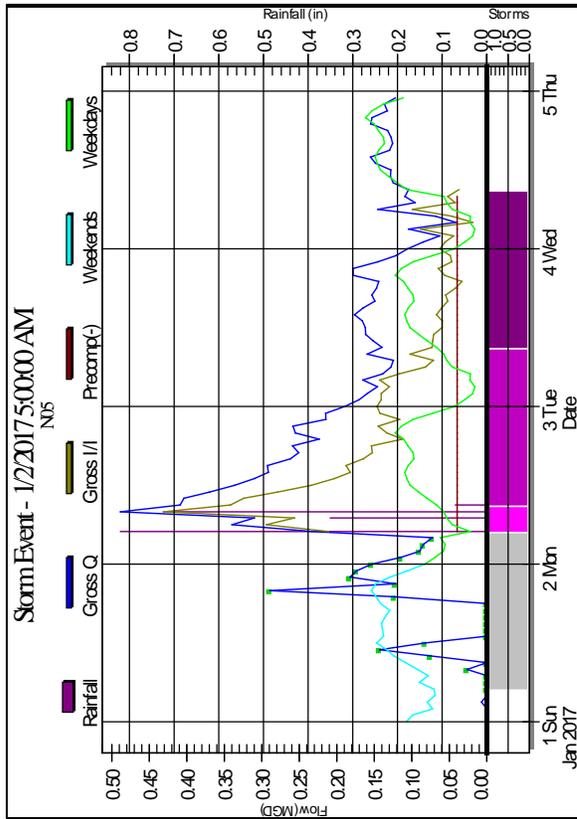
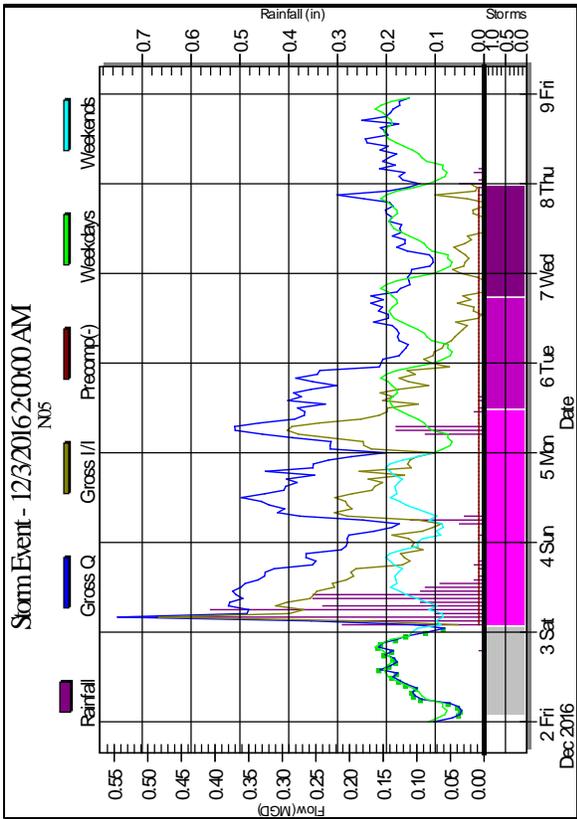
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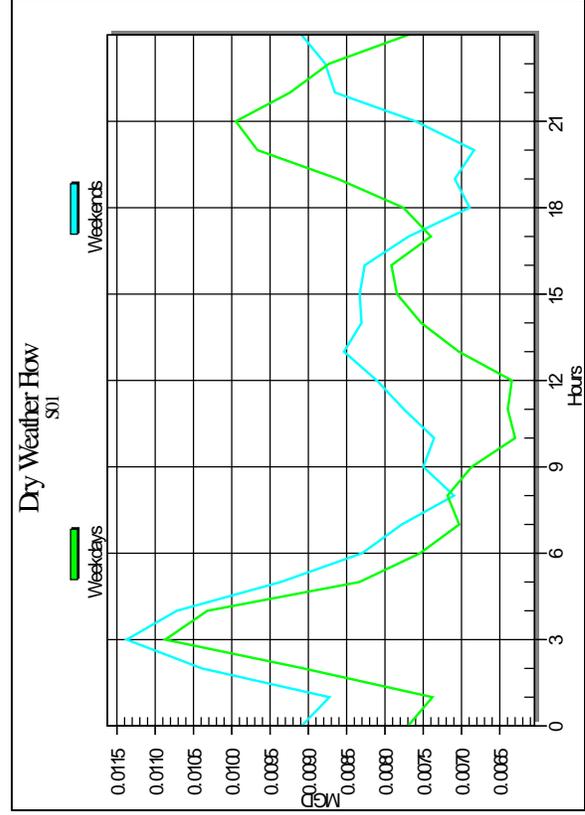
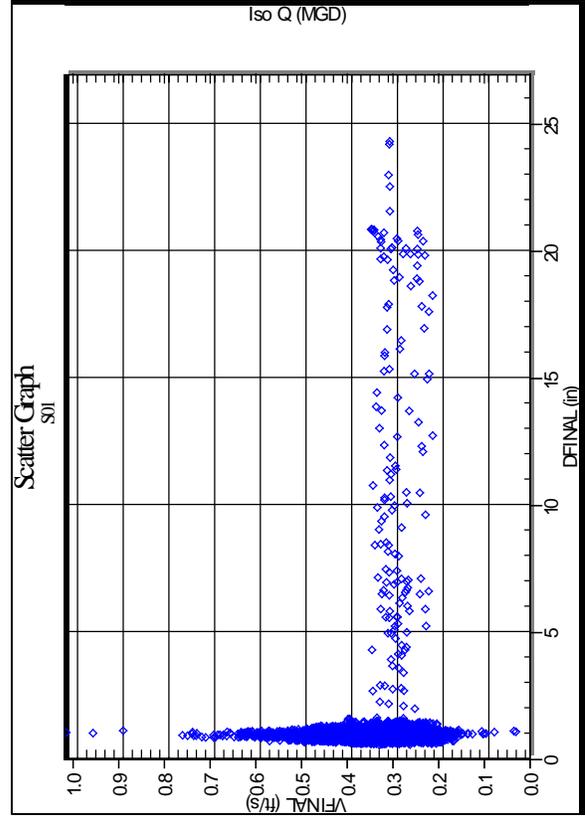
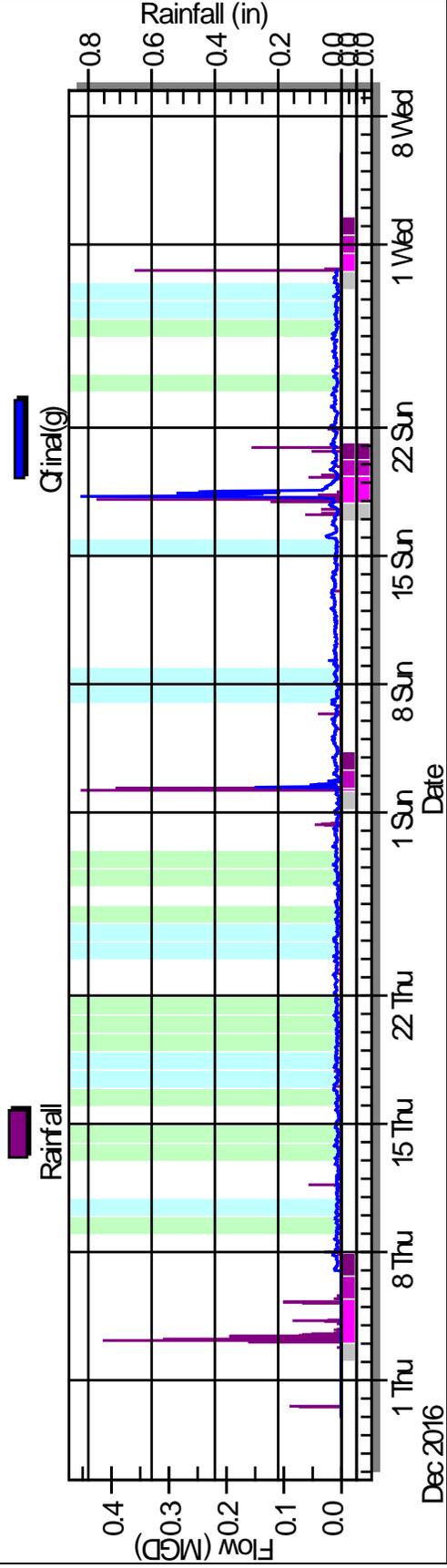


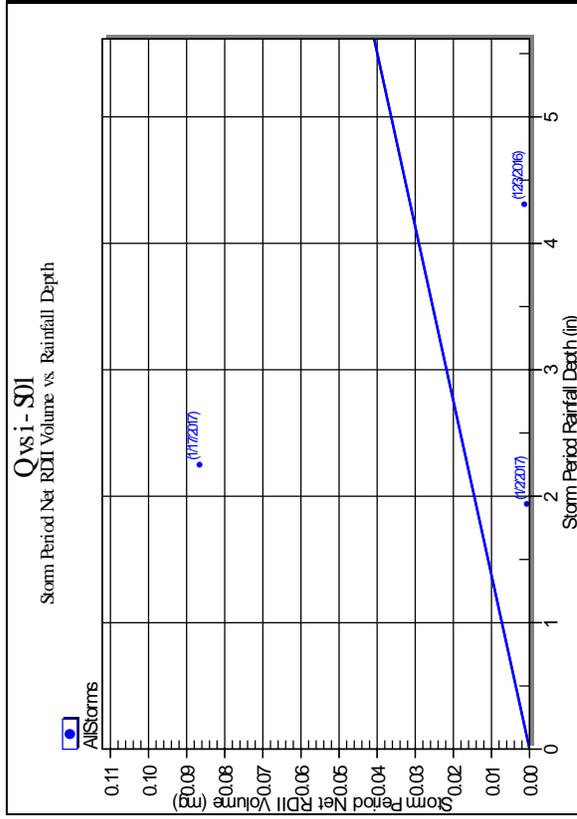
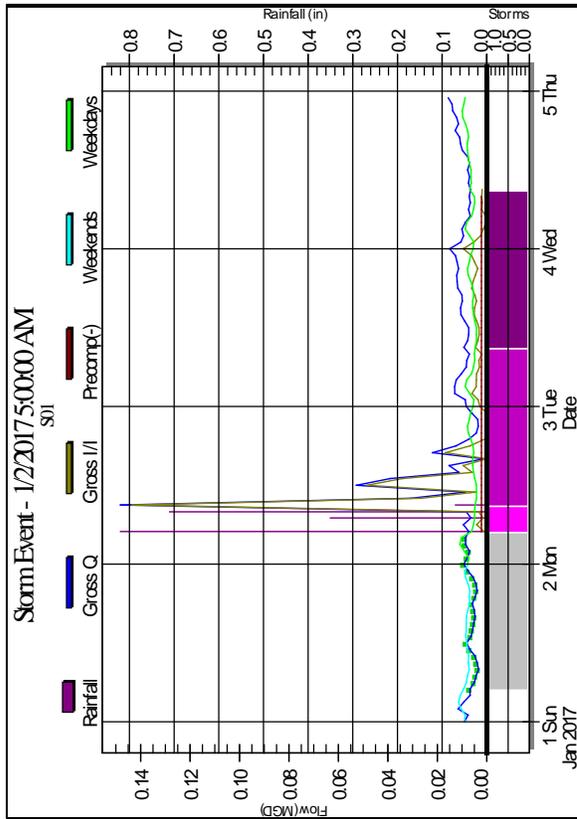
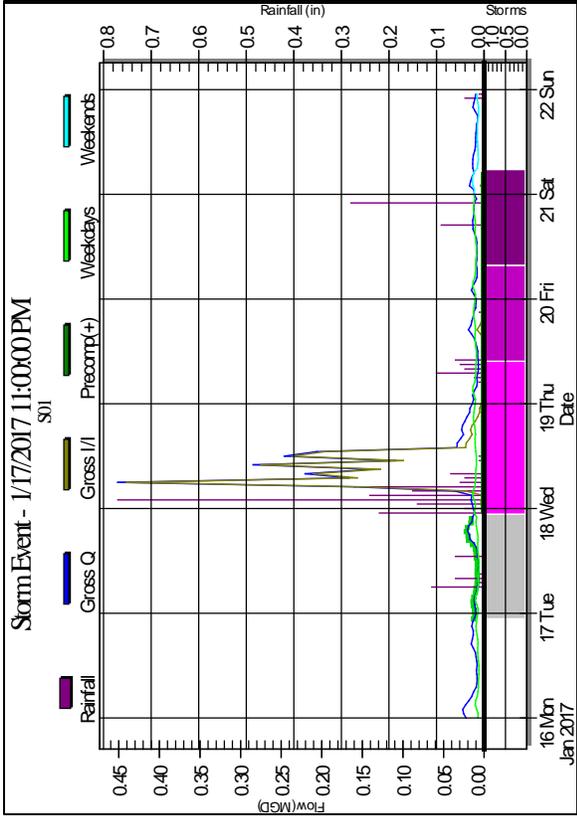
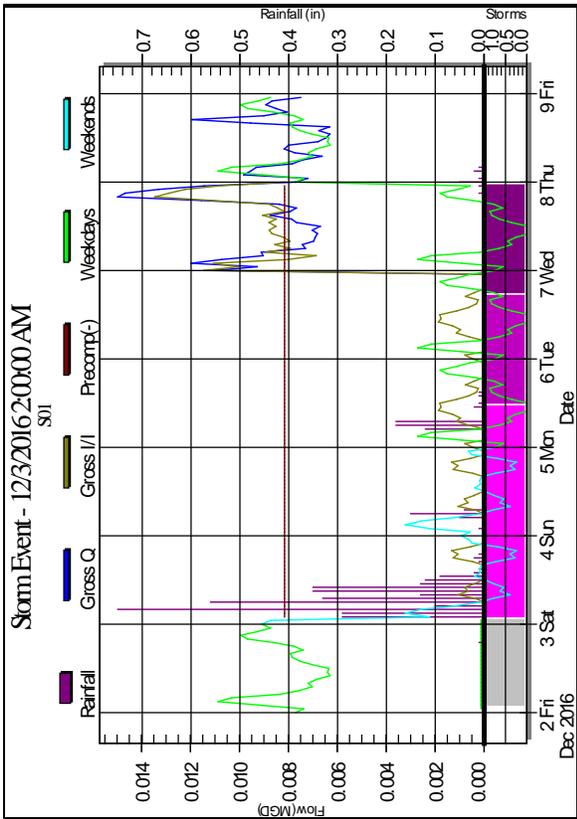
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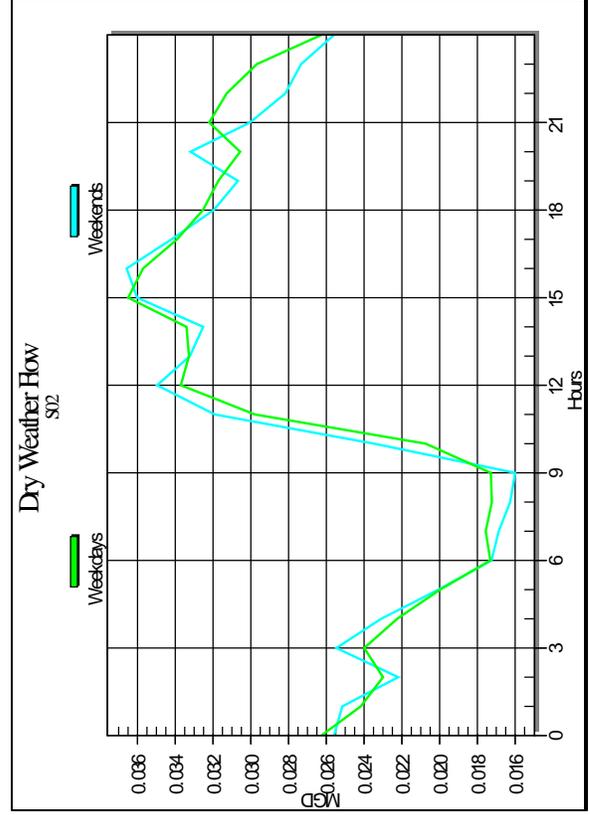
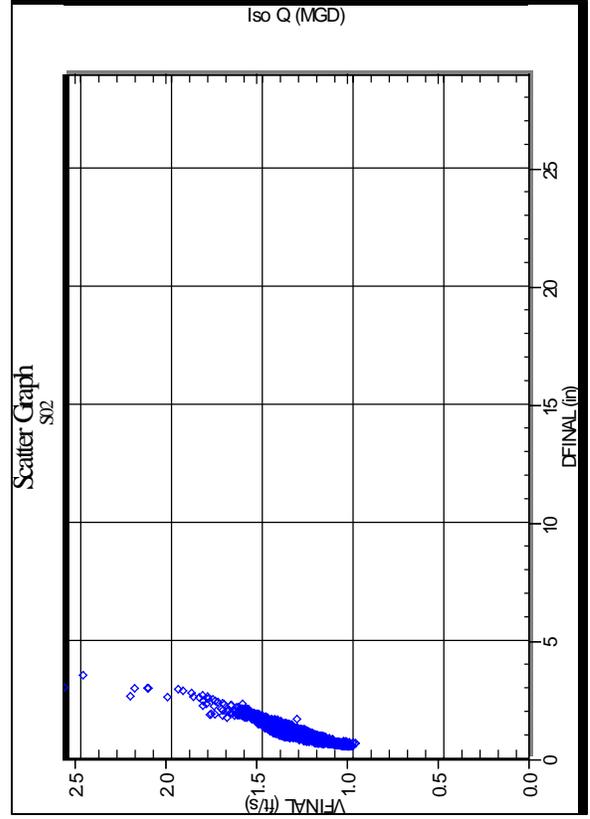
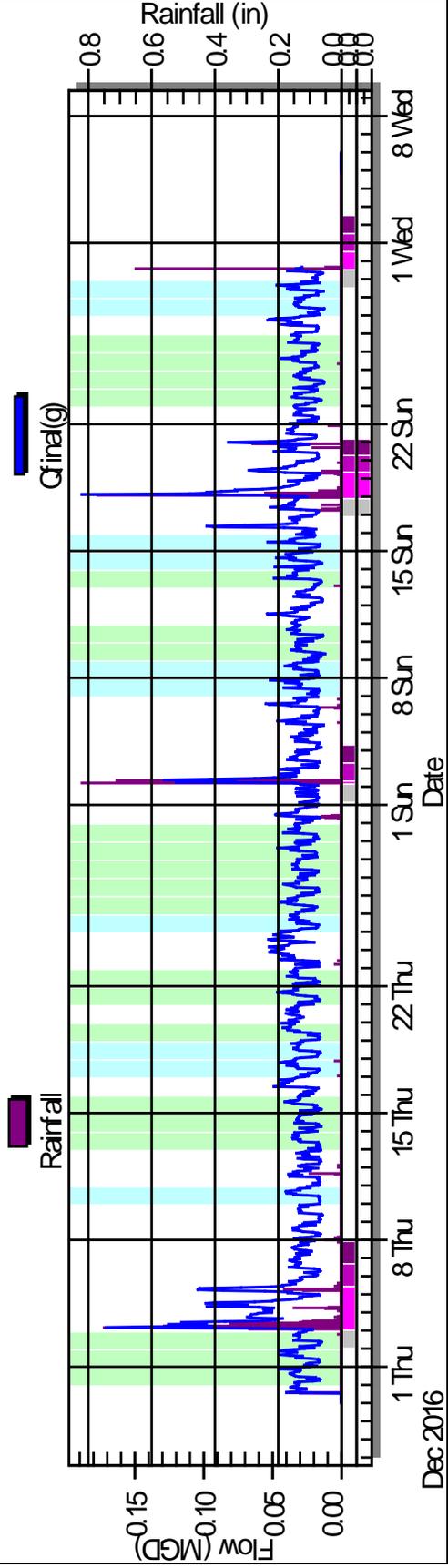


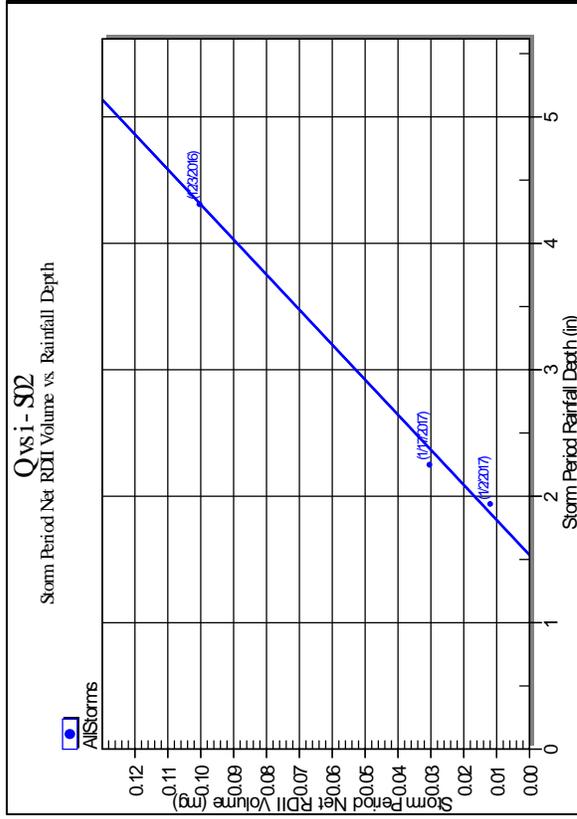
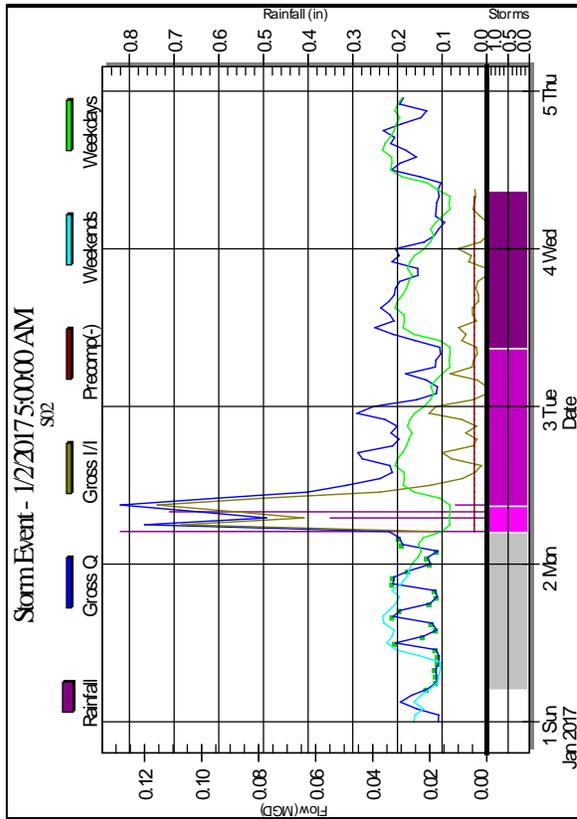
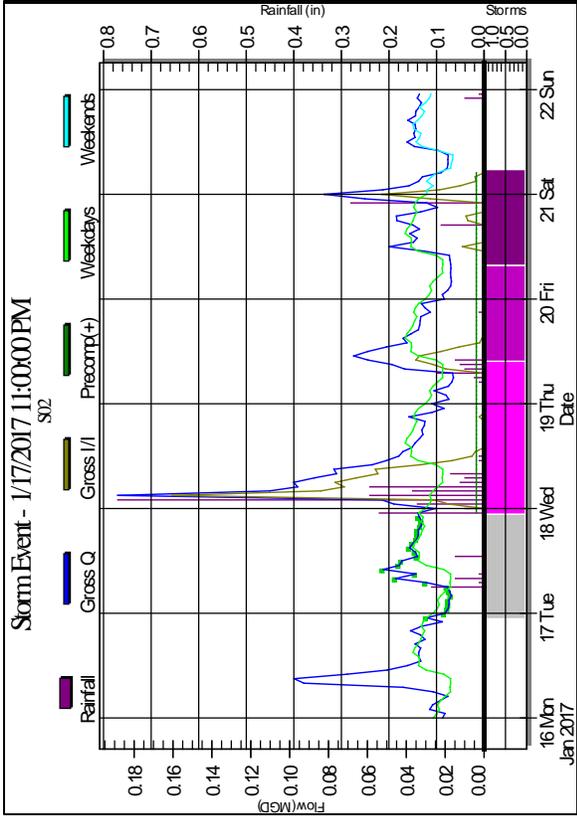
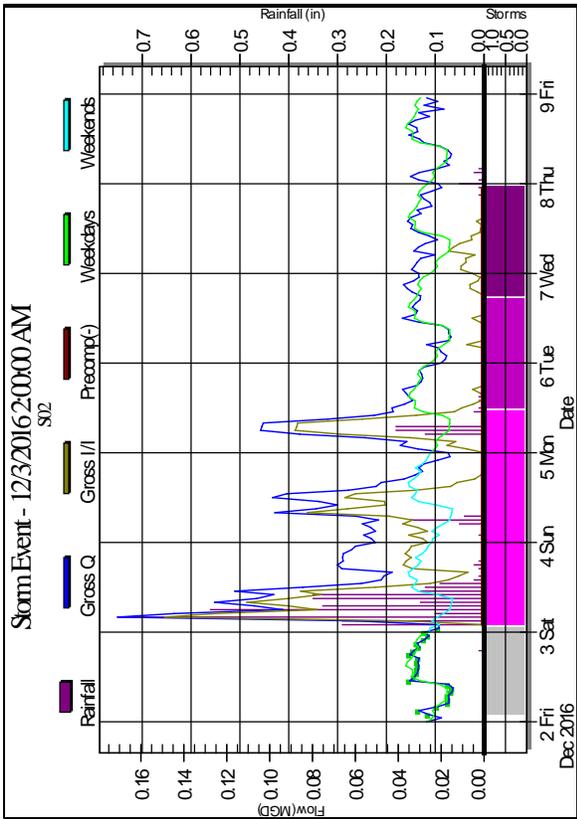
Pipe Flow S01



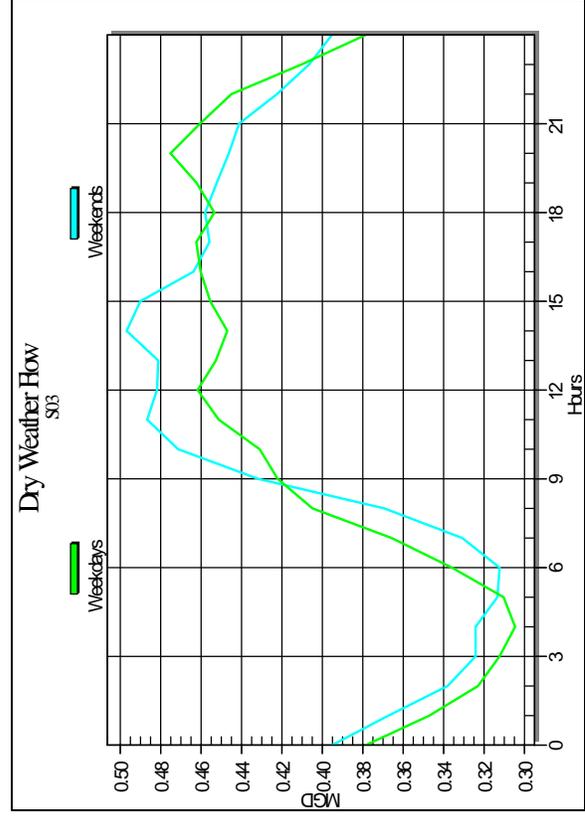
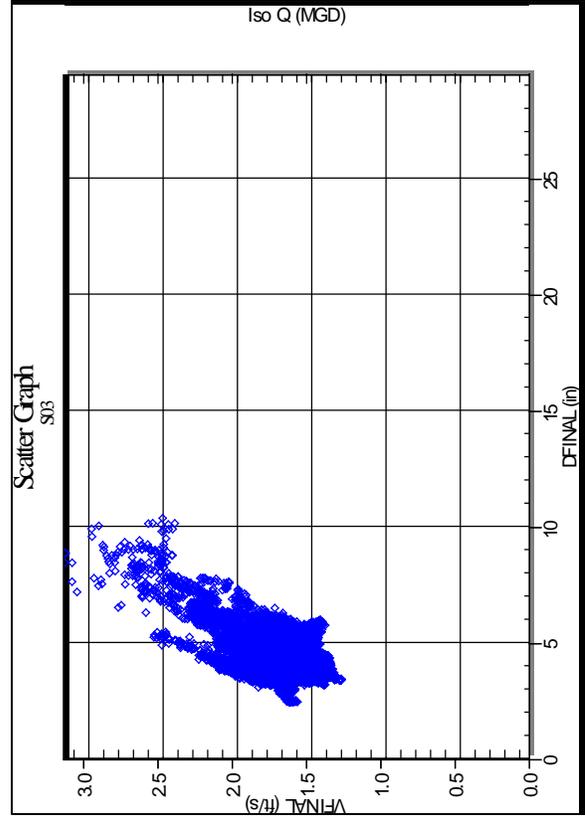
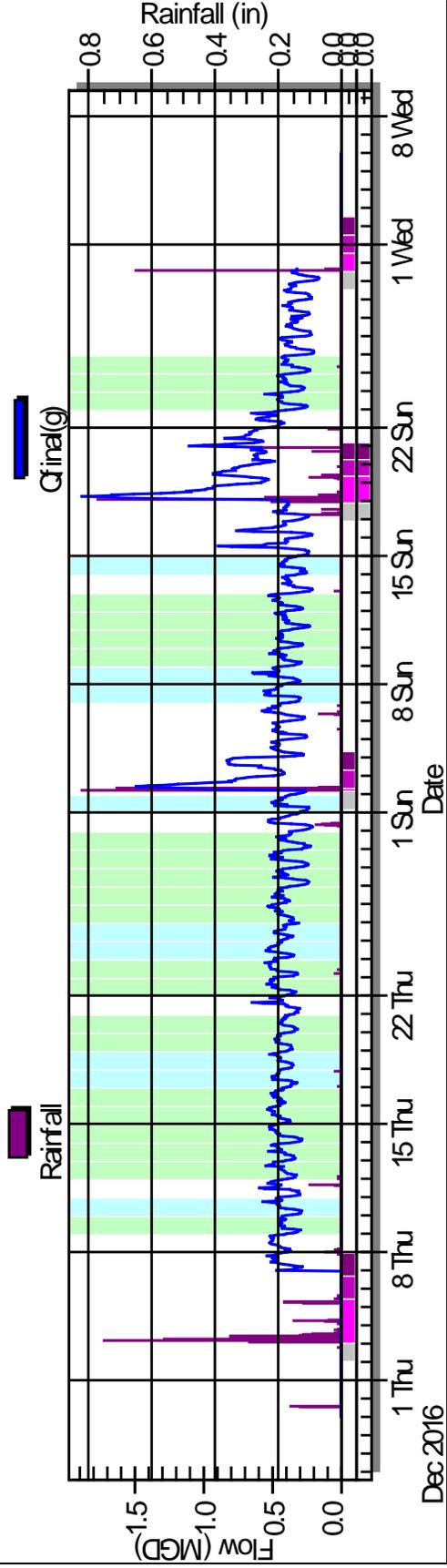


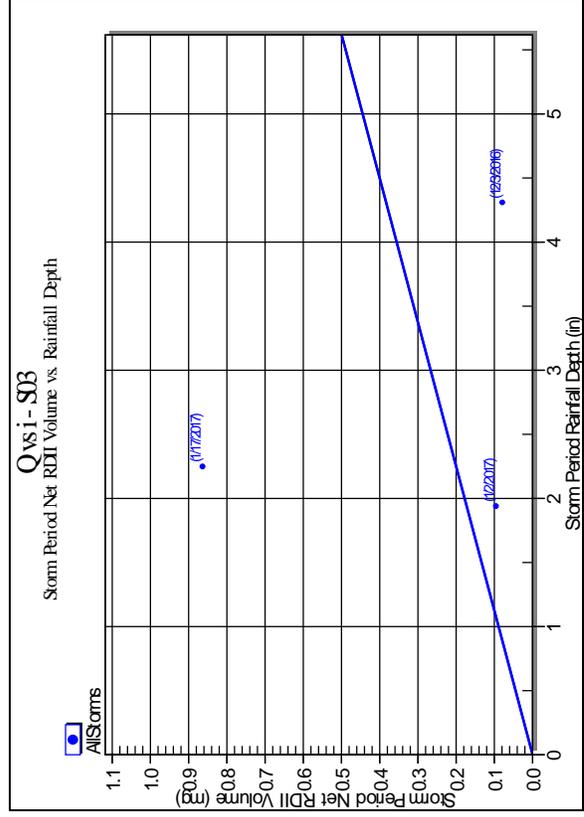
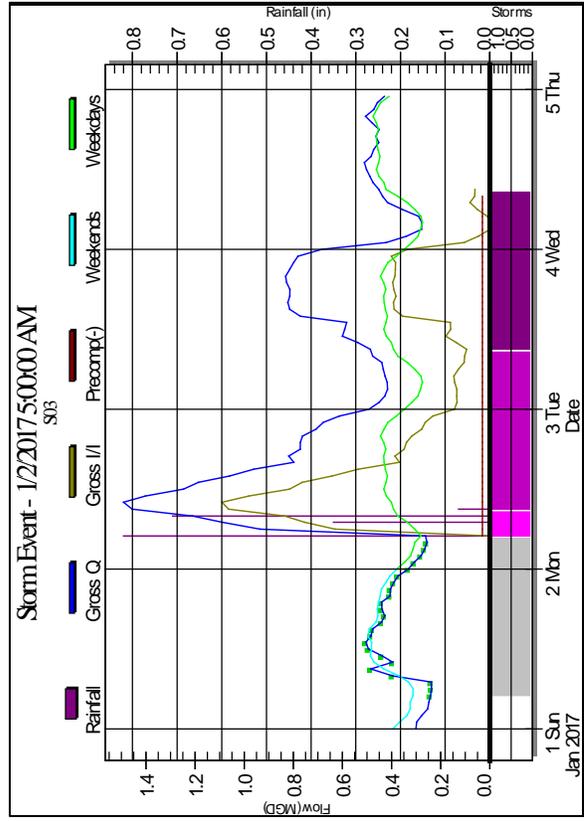
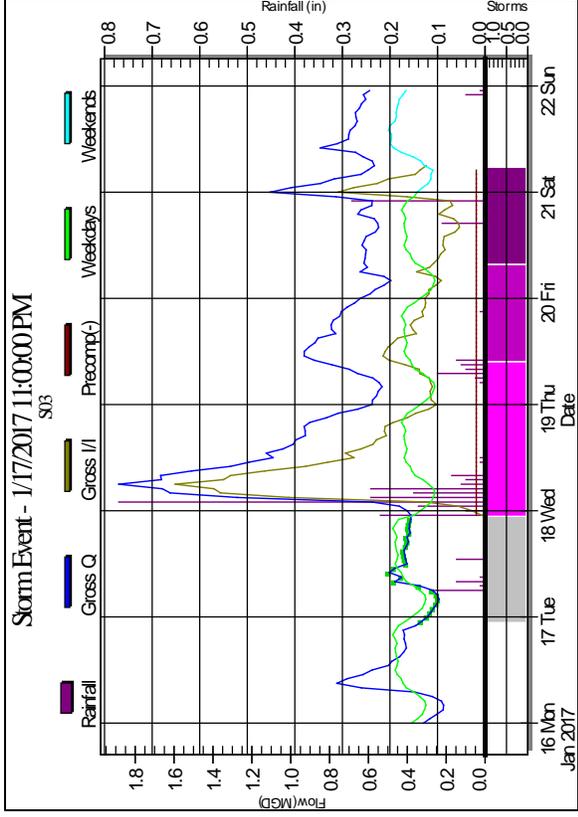
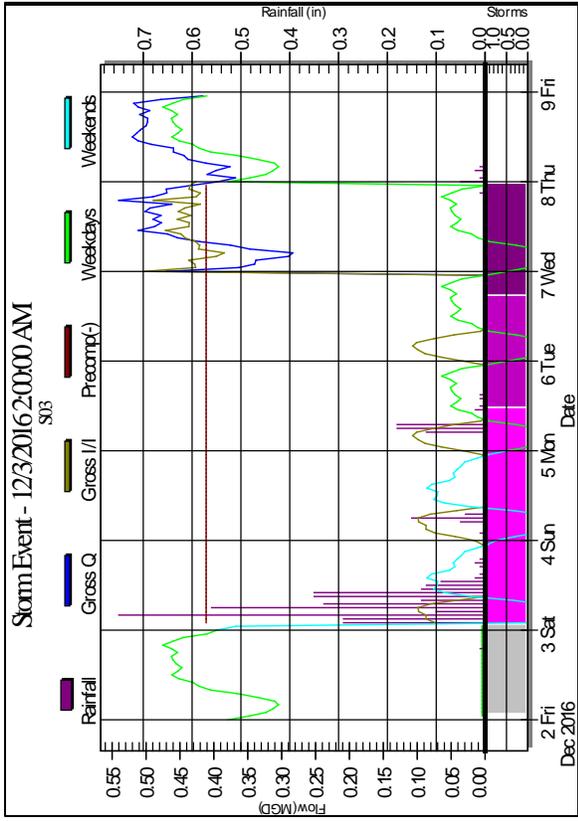
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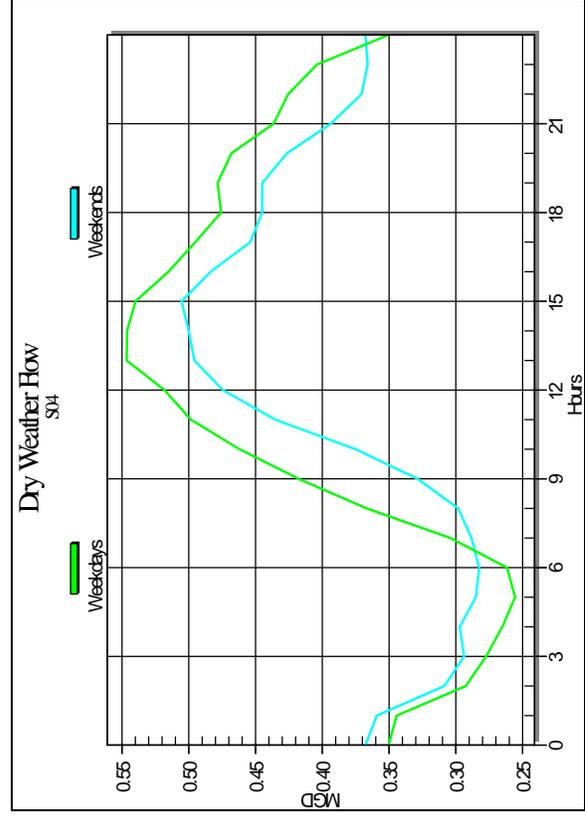
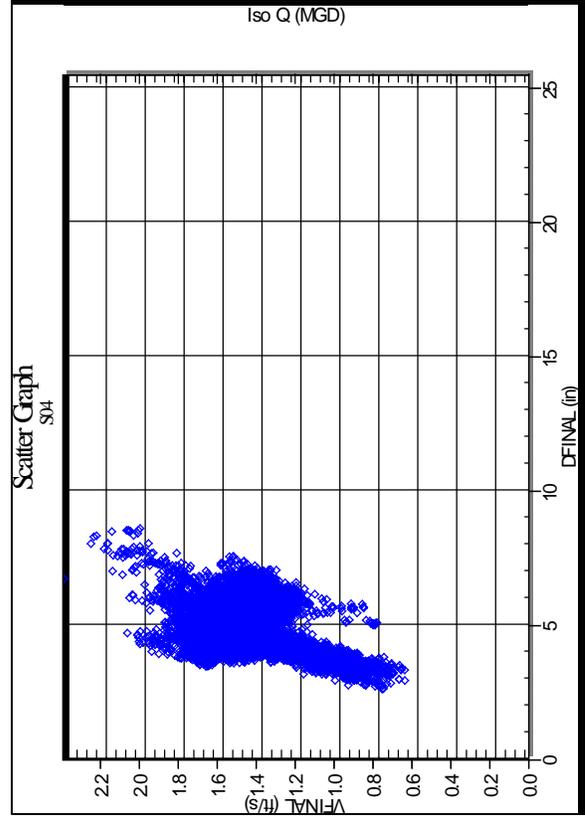
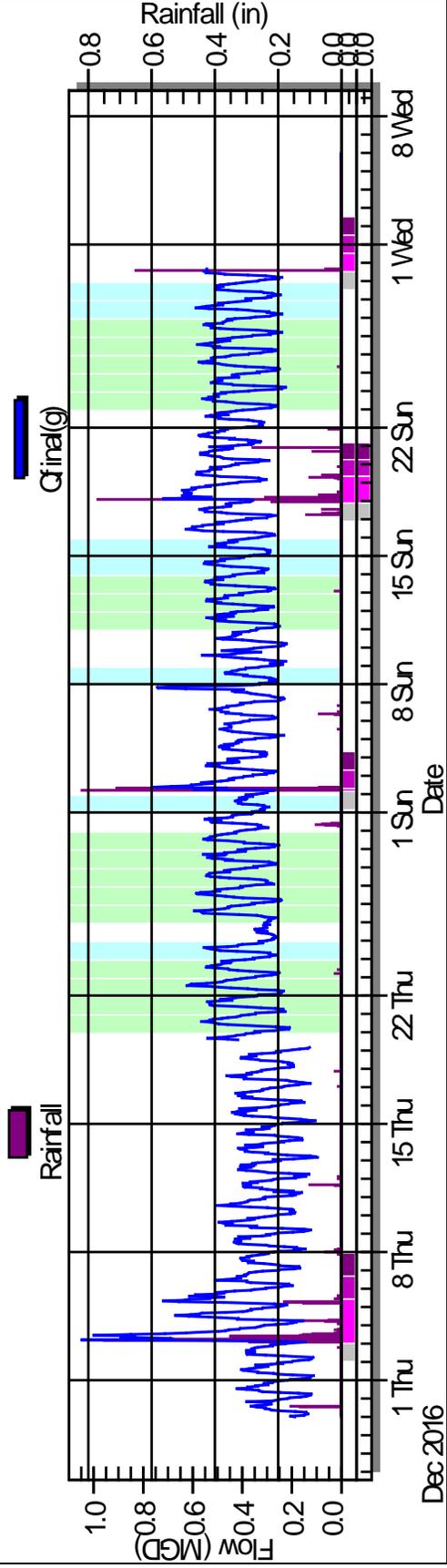


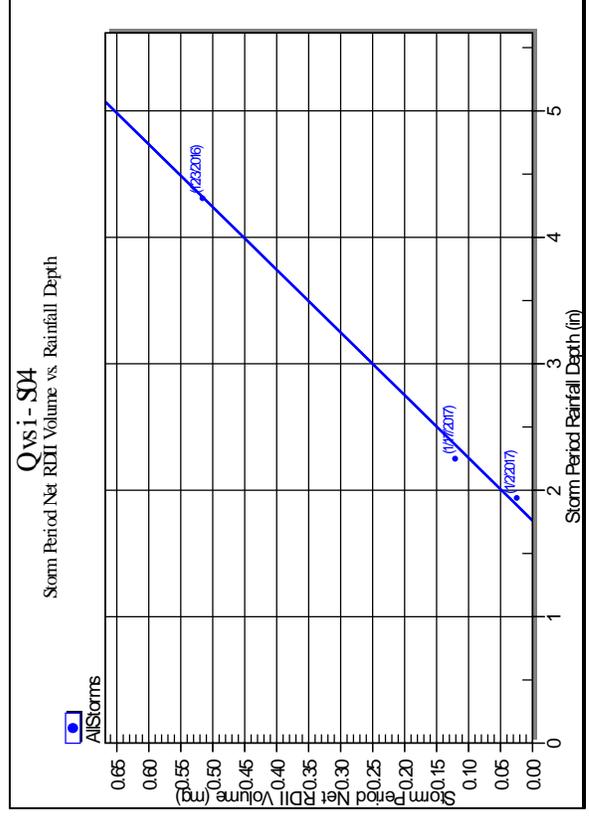
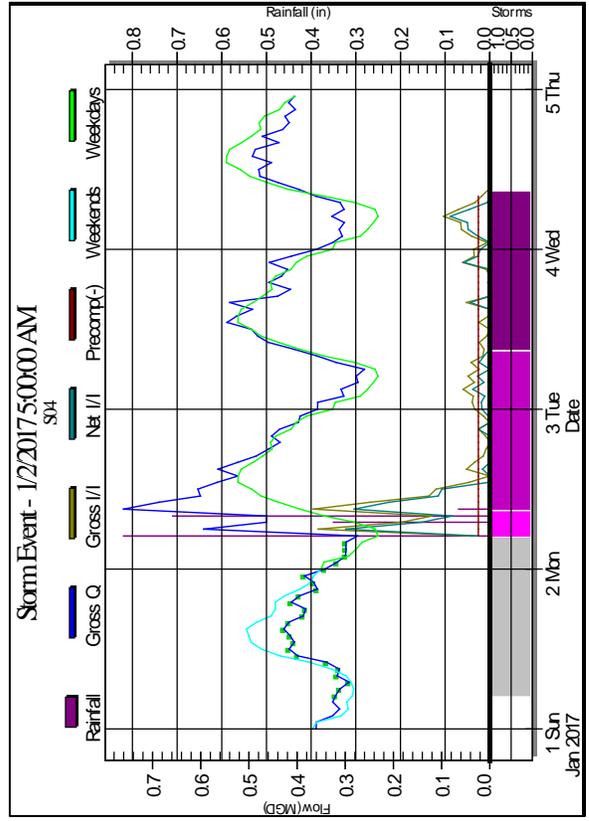
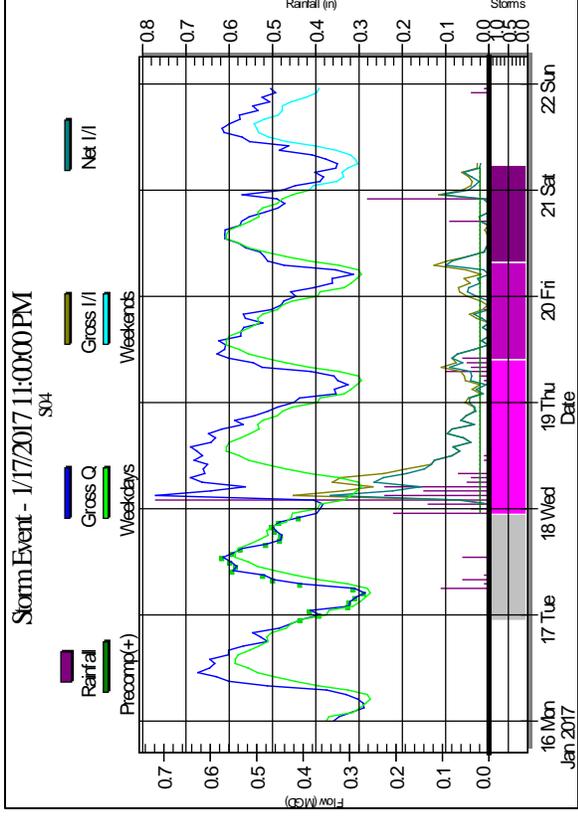
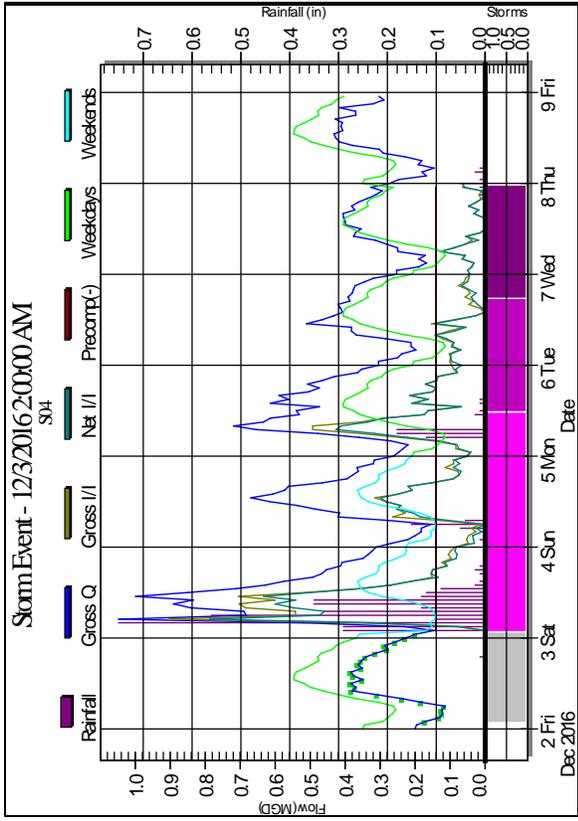
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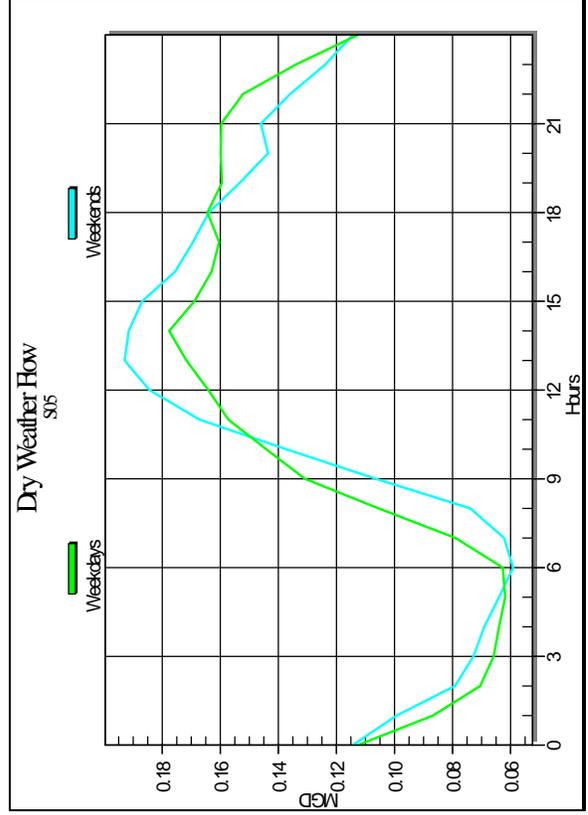
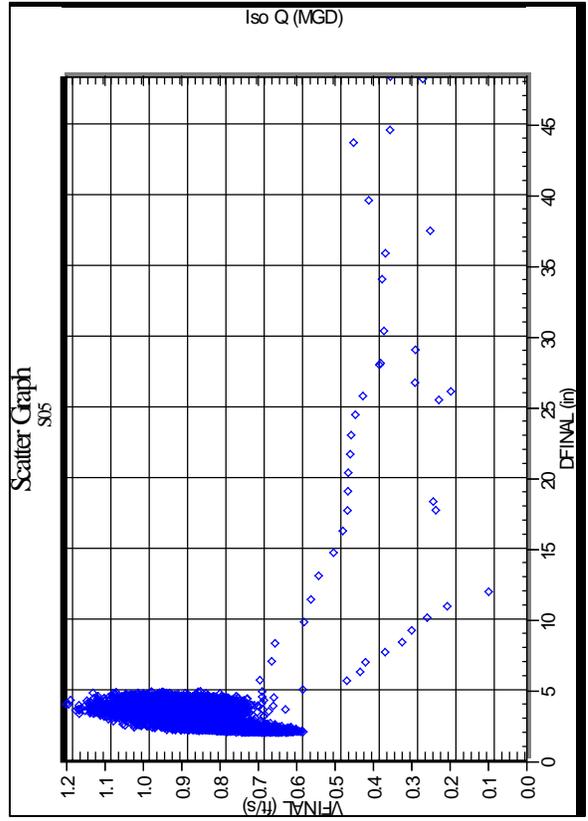
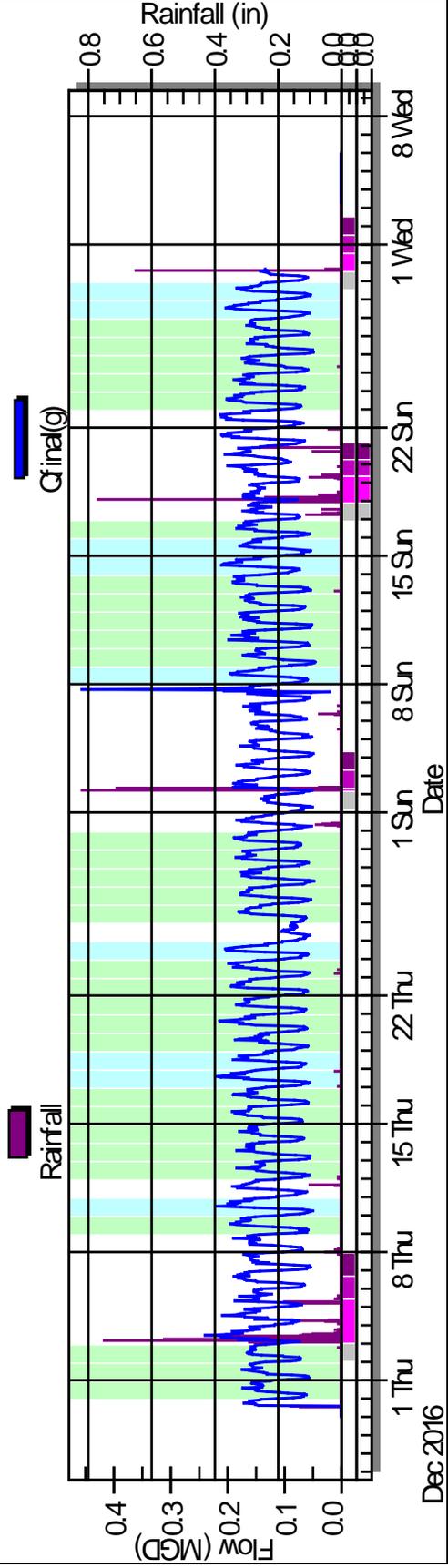


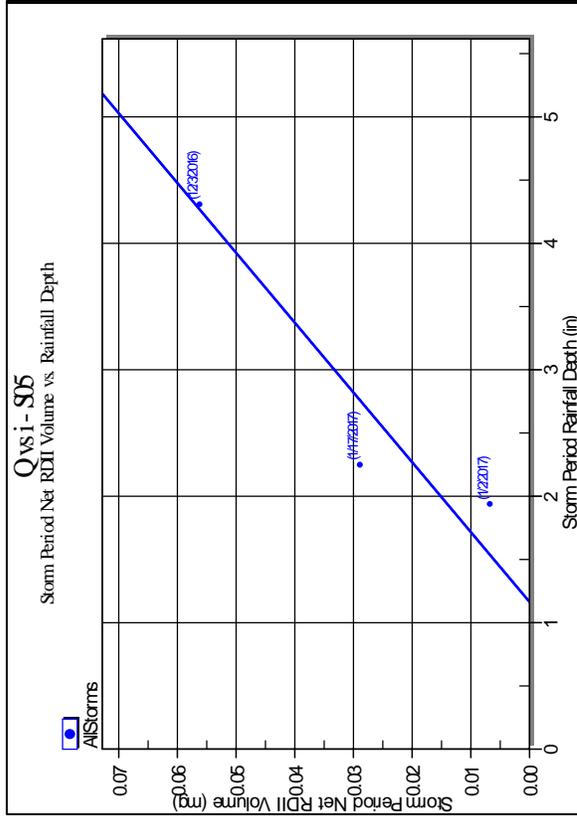
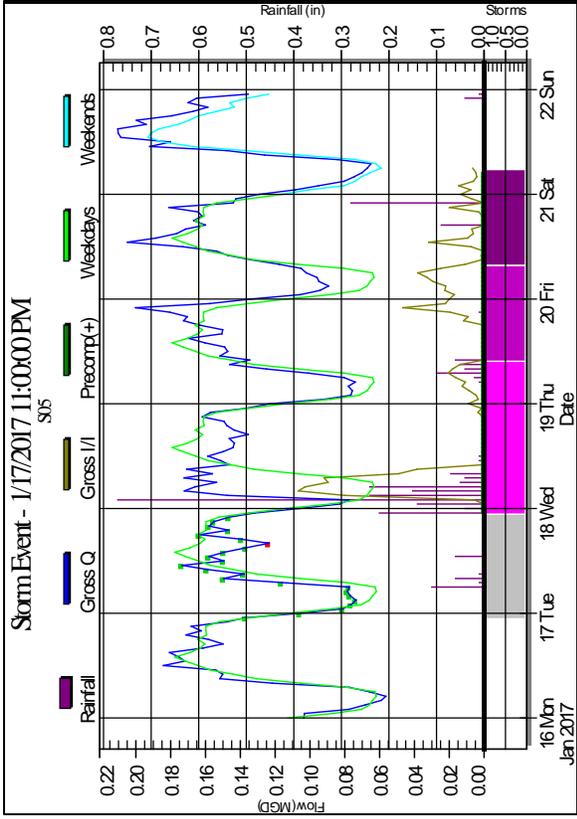
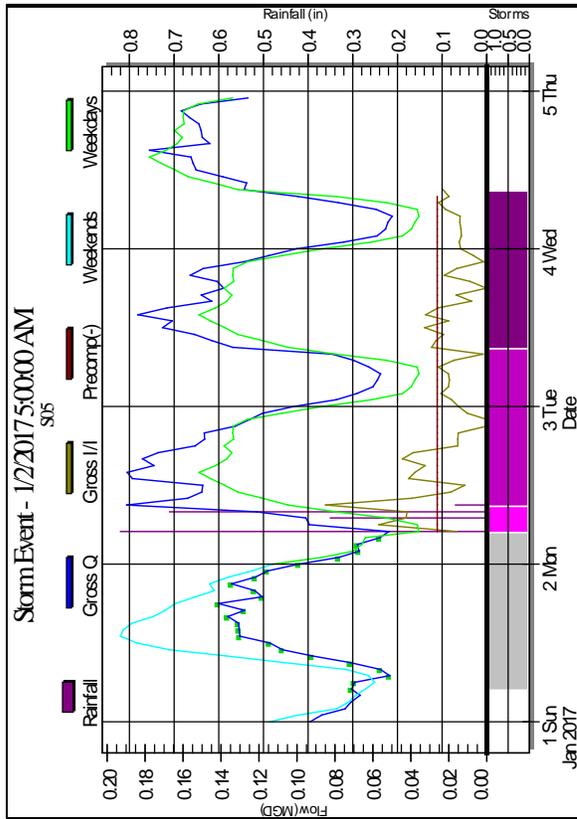
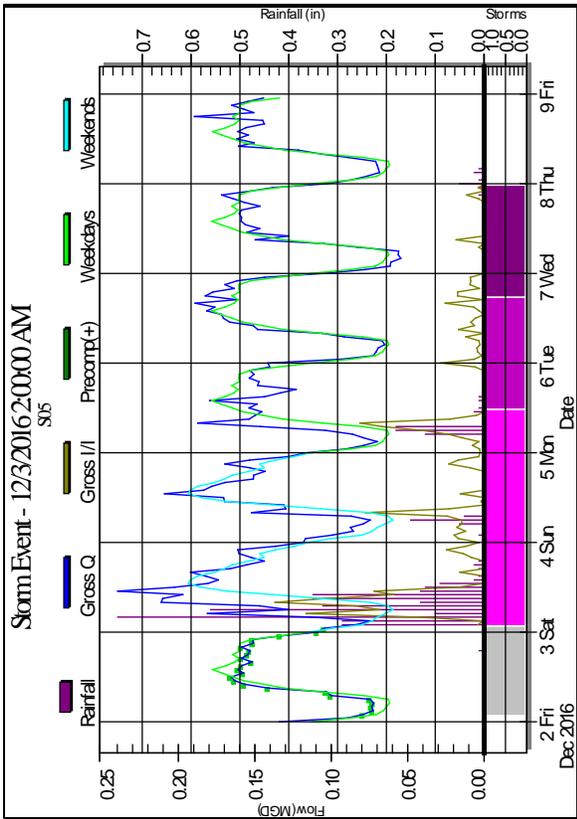
Pipe Flow S04





Pipe Flow S05



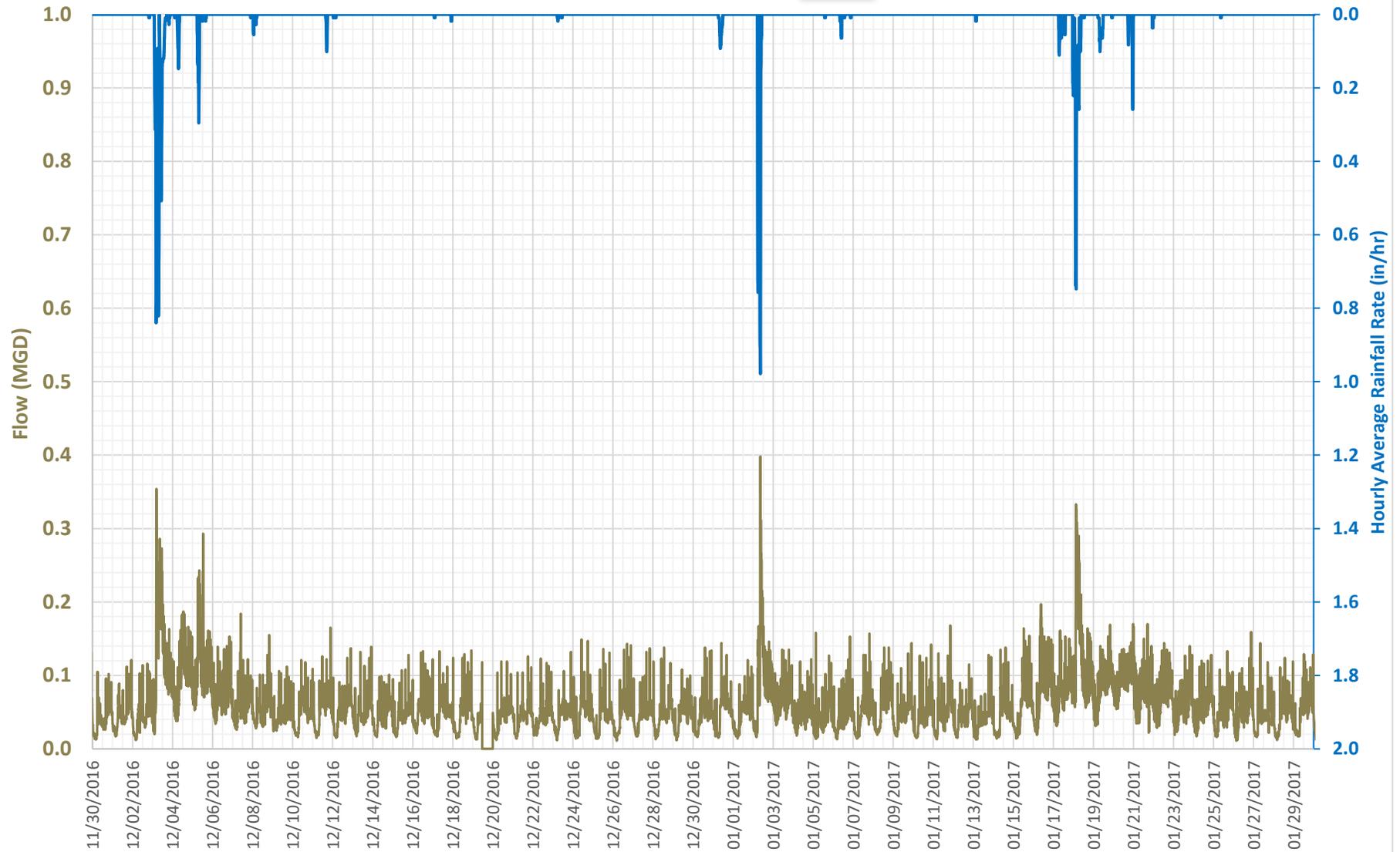


APPENDIX D
Hydrographs and Flow Depth Plots for Wastewater Flow Monitors

City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data
Flow Monitor ID: **N-01**



Recorded Flow Rate

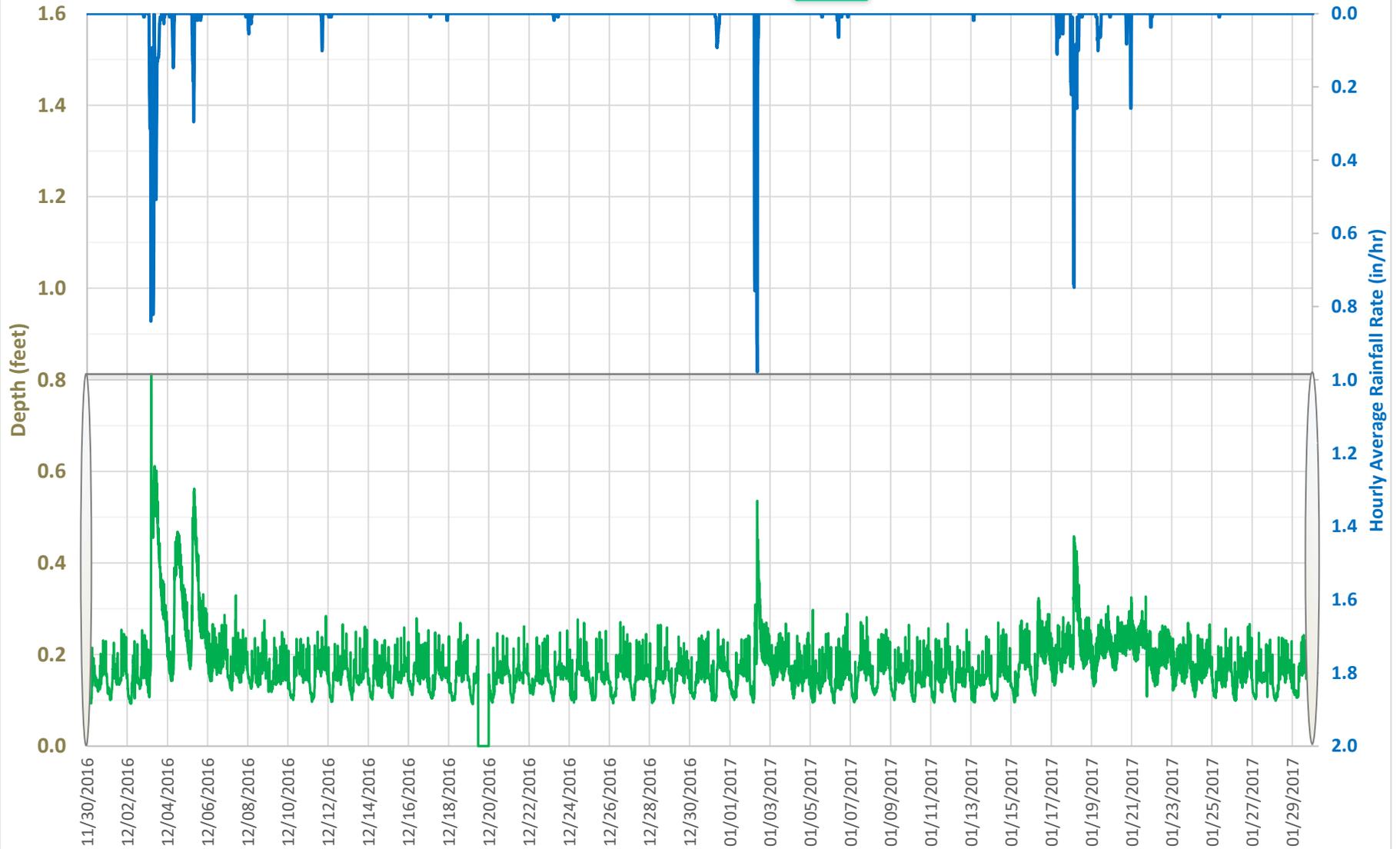


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Depth of Flow

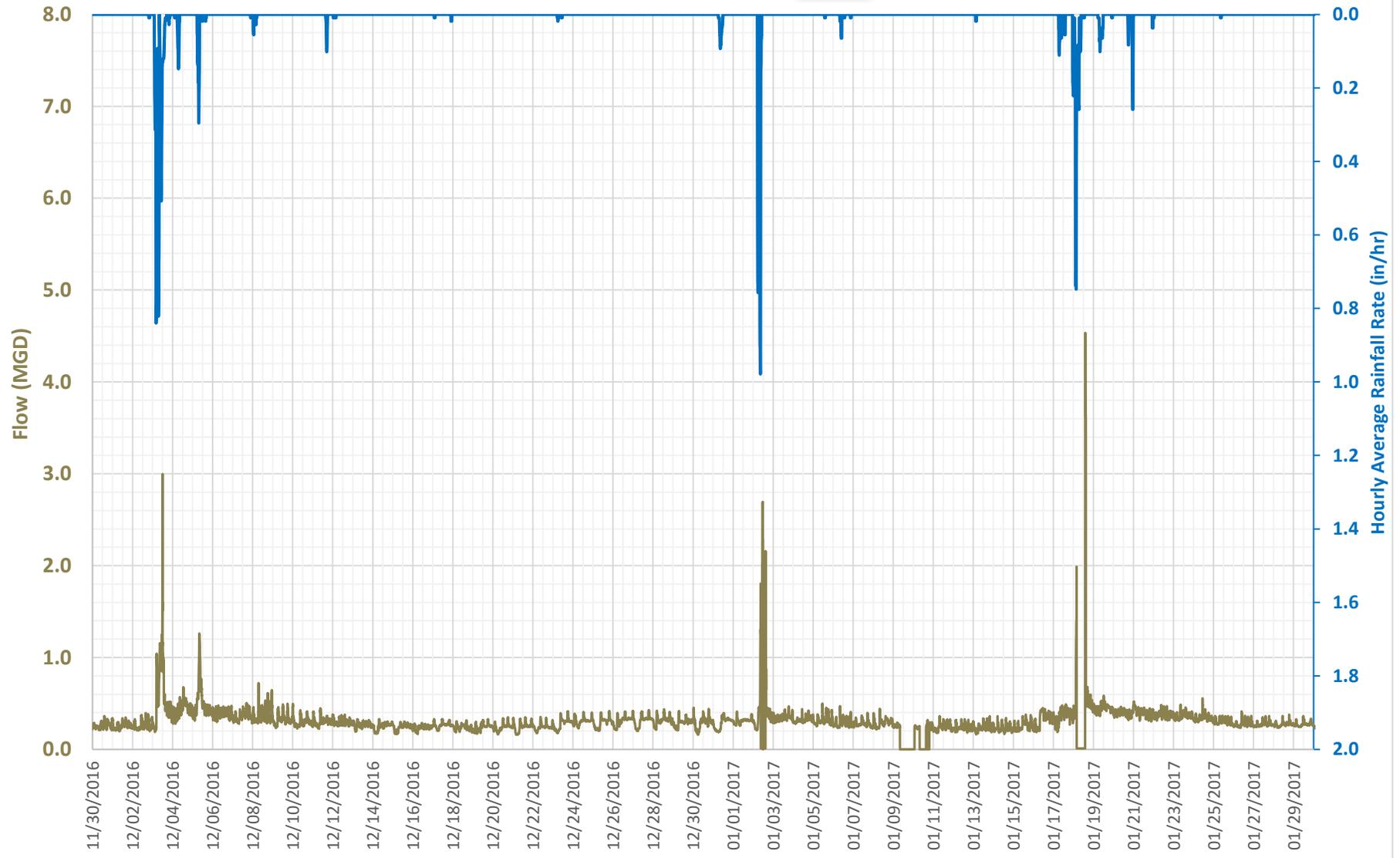
Flow Monitor ID: **N-01**



City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data
Flow Monitor ID: **N-02**



Recorded Flow Rate

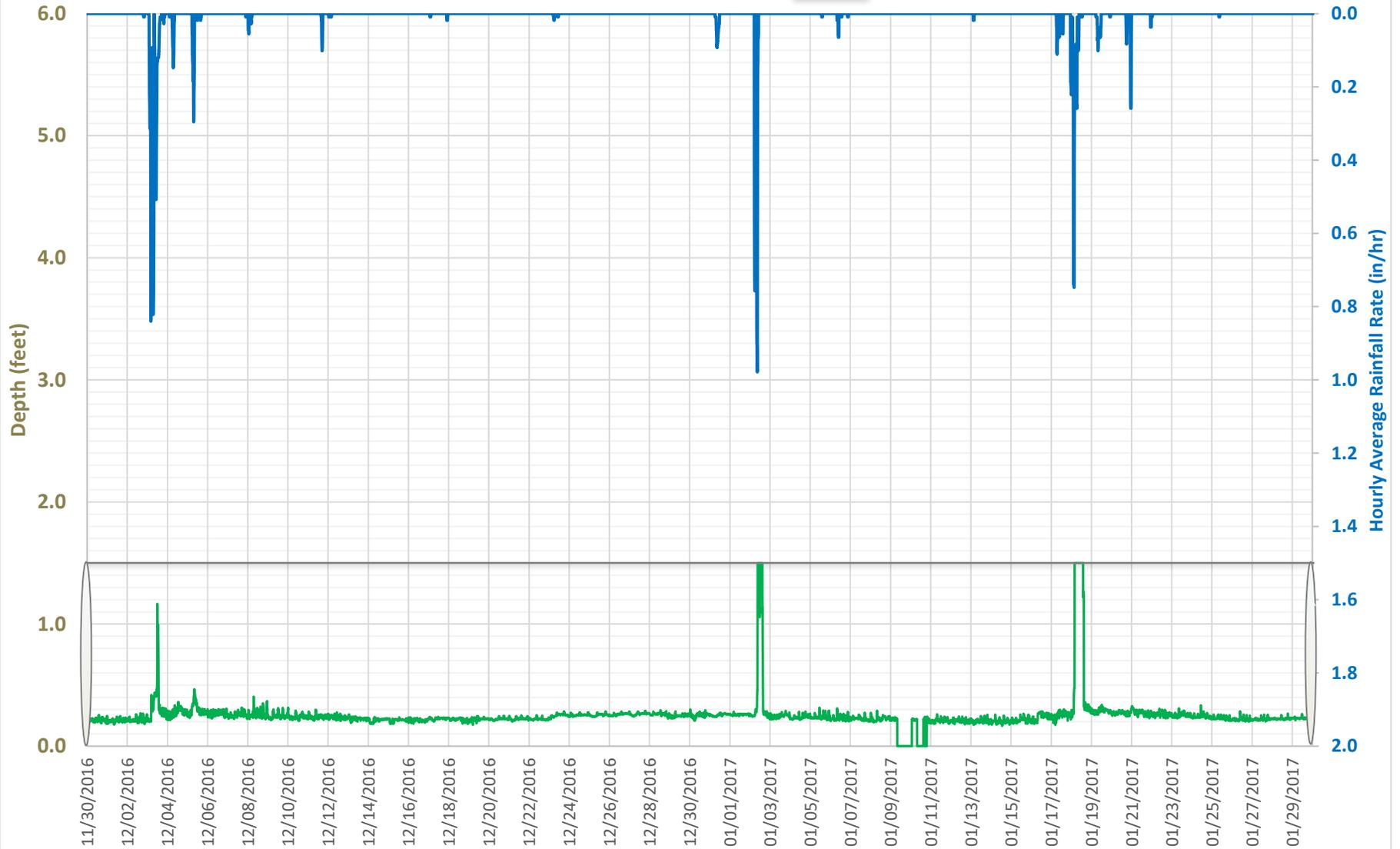


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Depth of Flow

Flow Monitor ID: **N-02**

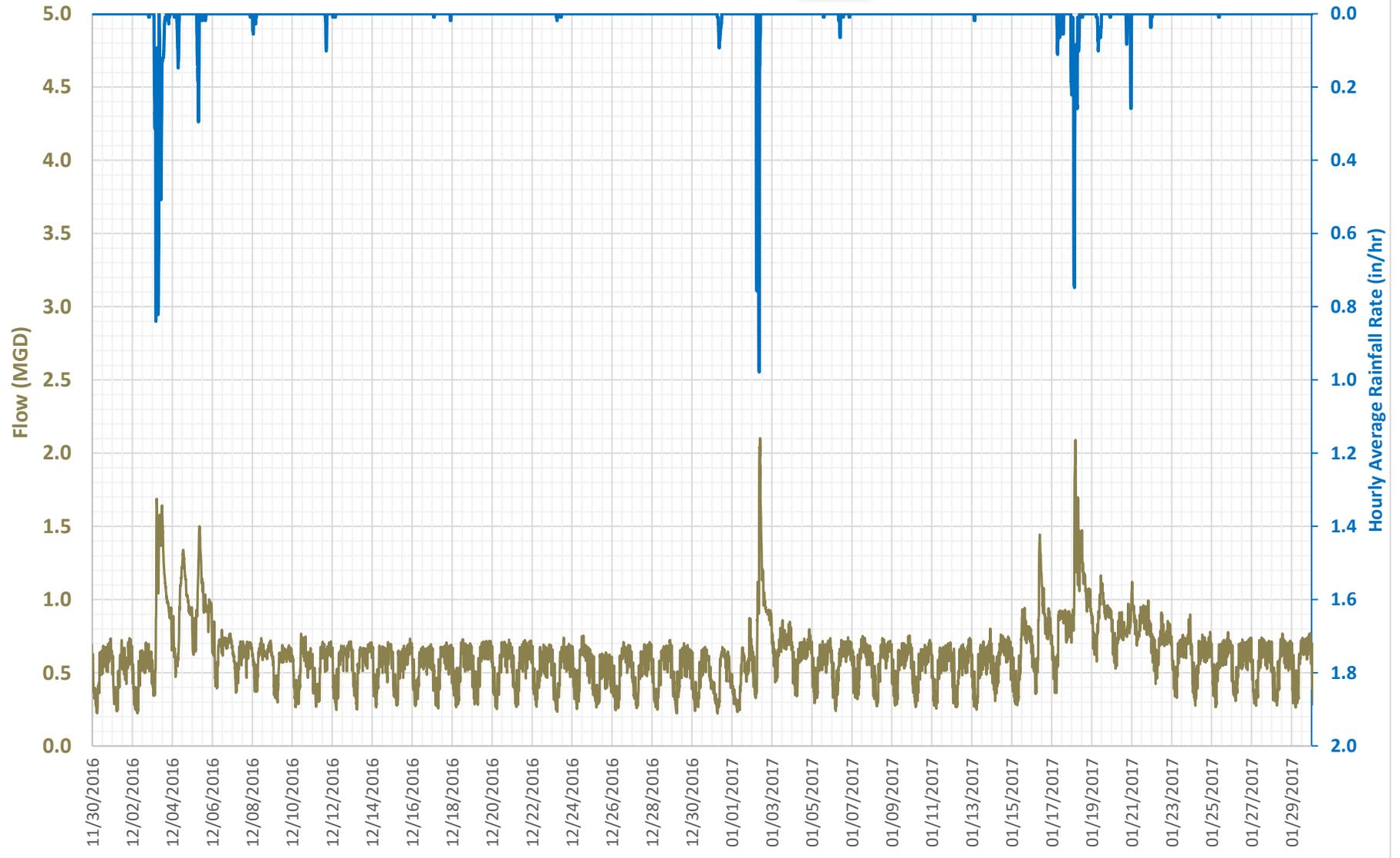


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Flow Rate

Flow Monitor ID: **N-03**

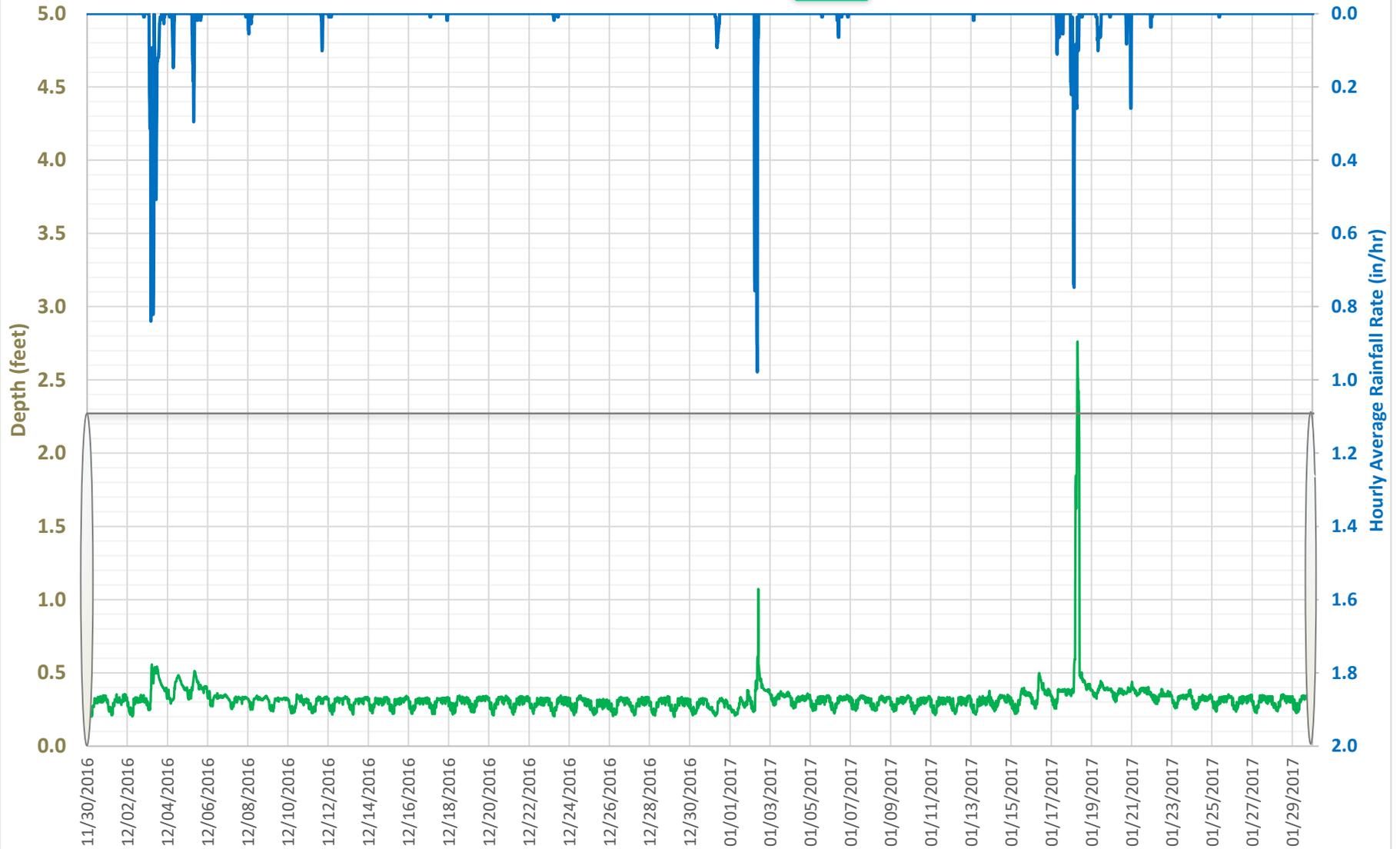


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Depth of Flow

Flow Monitor ID: **N-03**

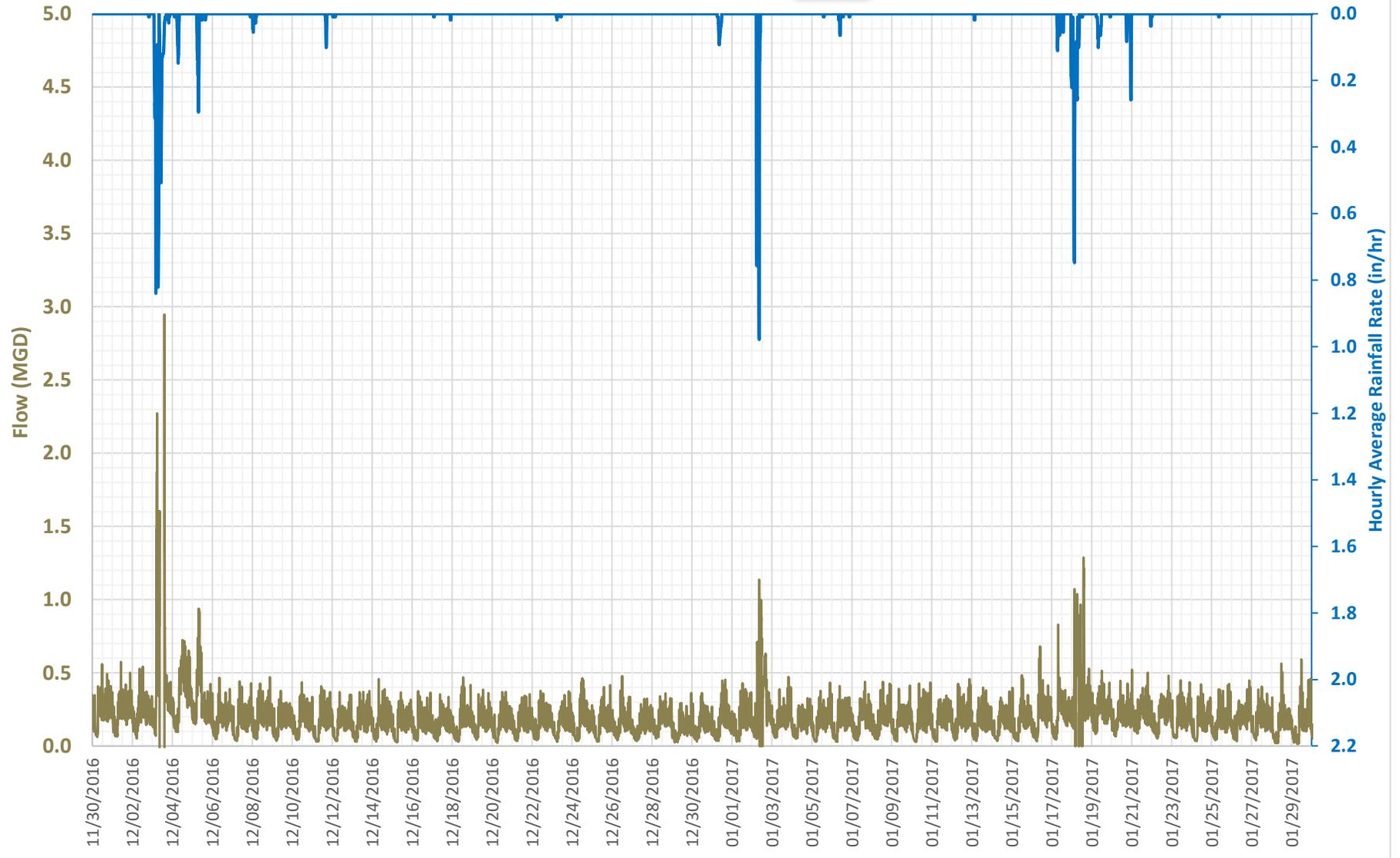


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Flow Rate

Flow Monitor ID: **N-04**

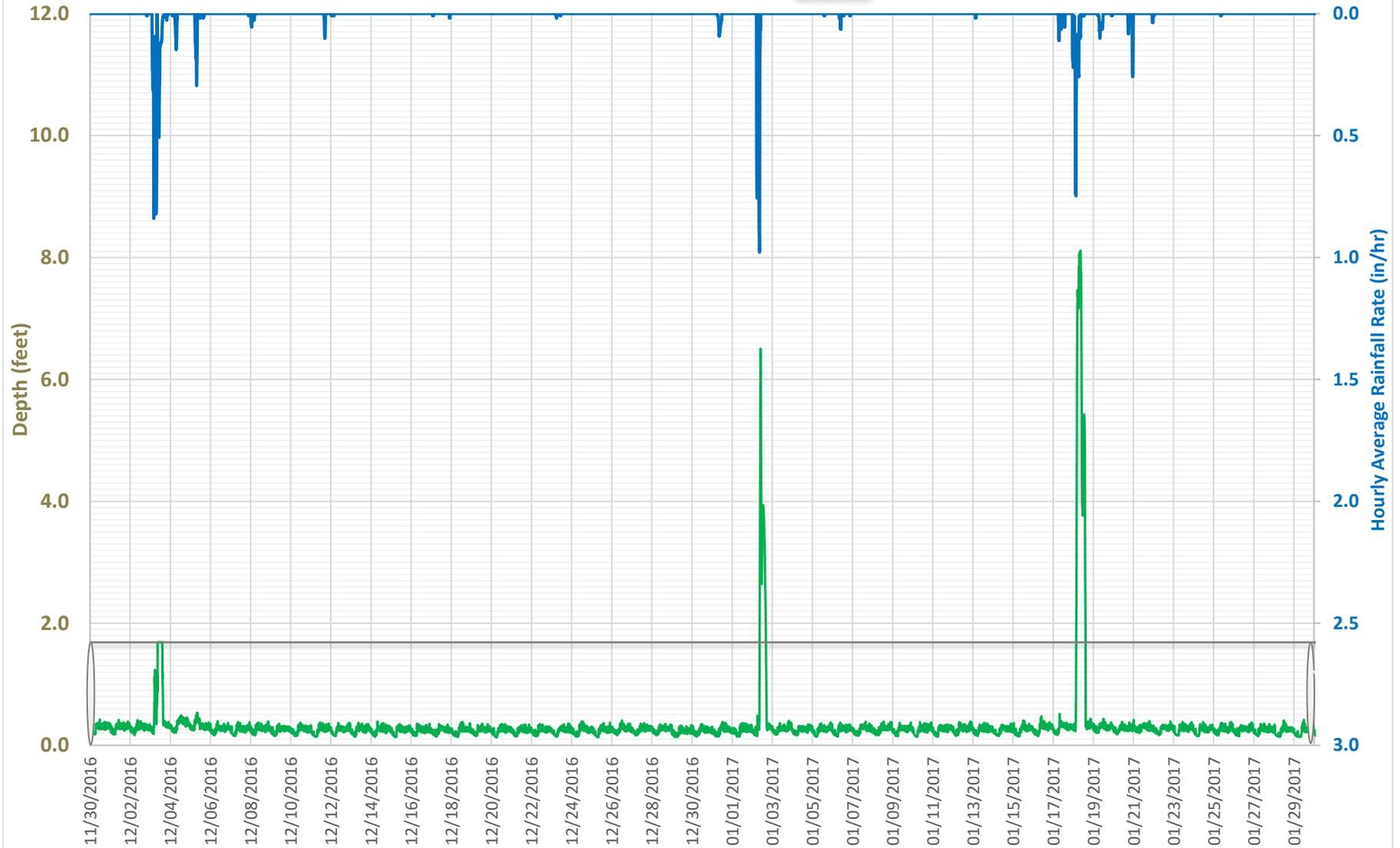


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Depth of Flow

Flow Monitor ID: **N-04**

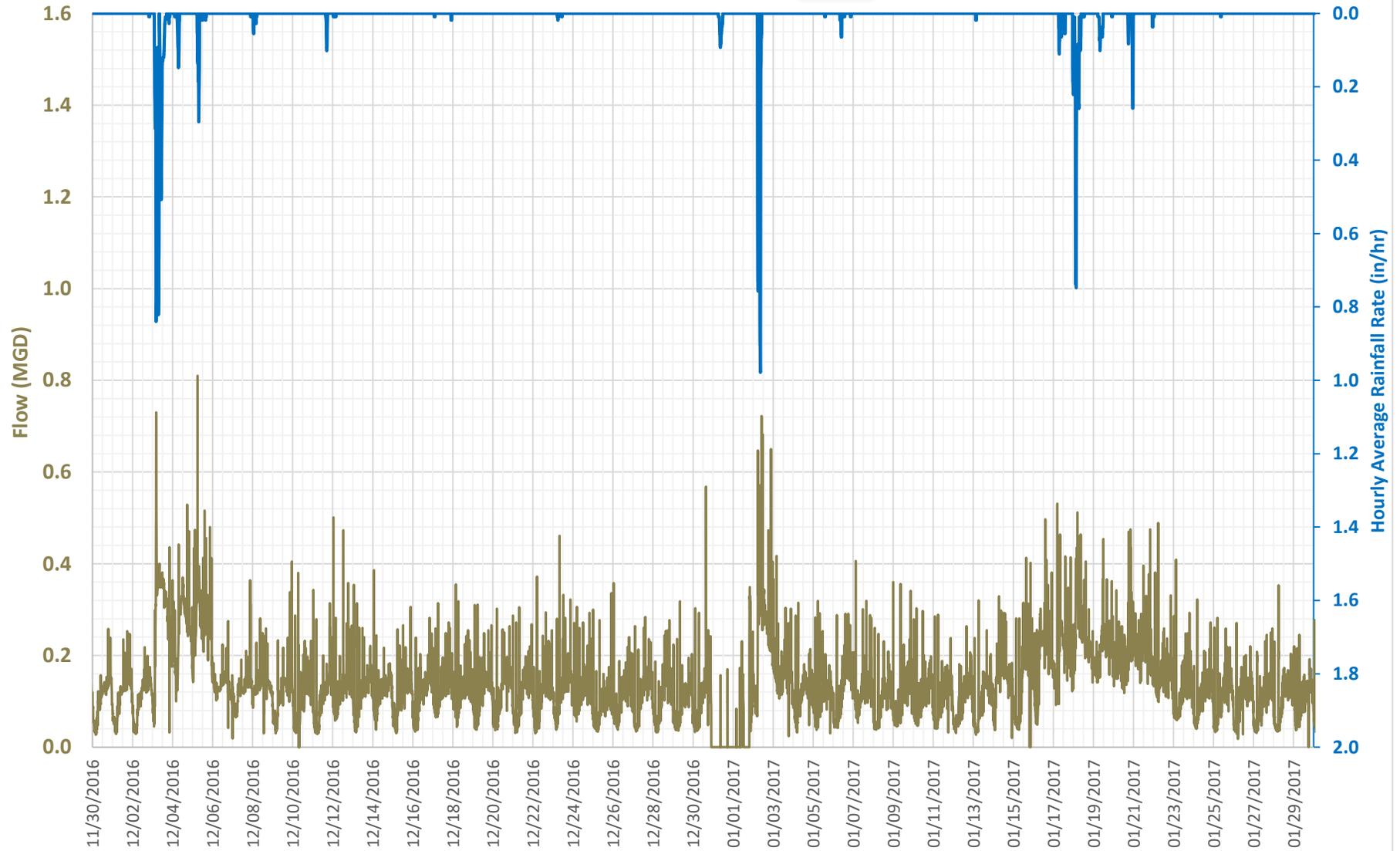


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Flow Rate

Flow Monitor ID: **N-05**

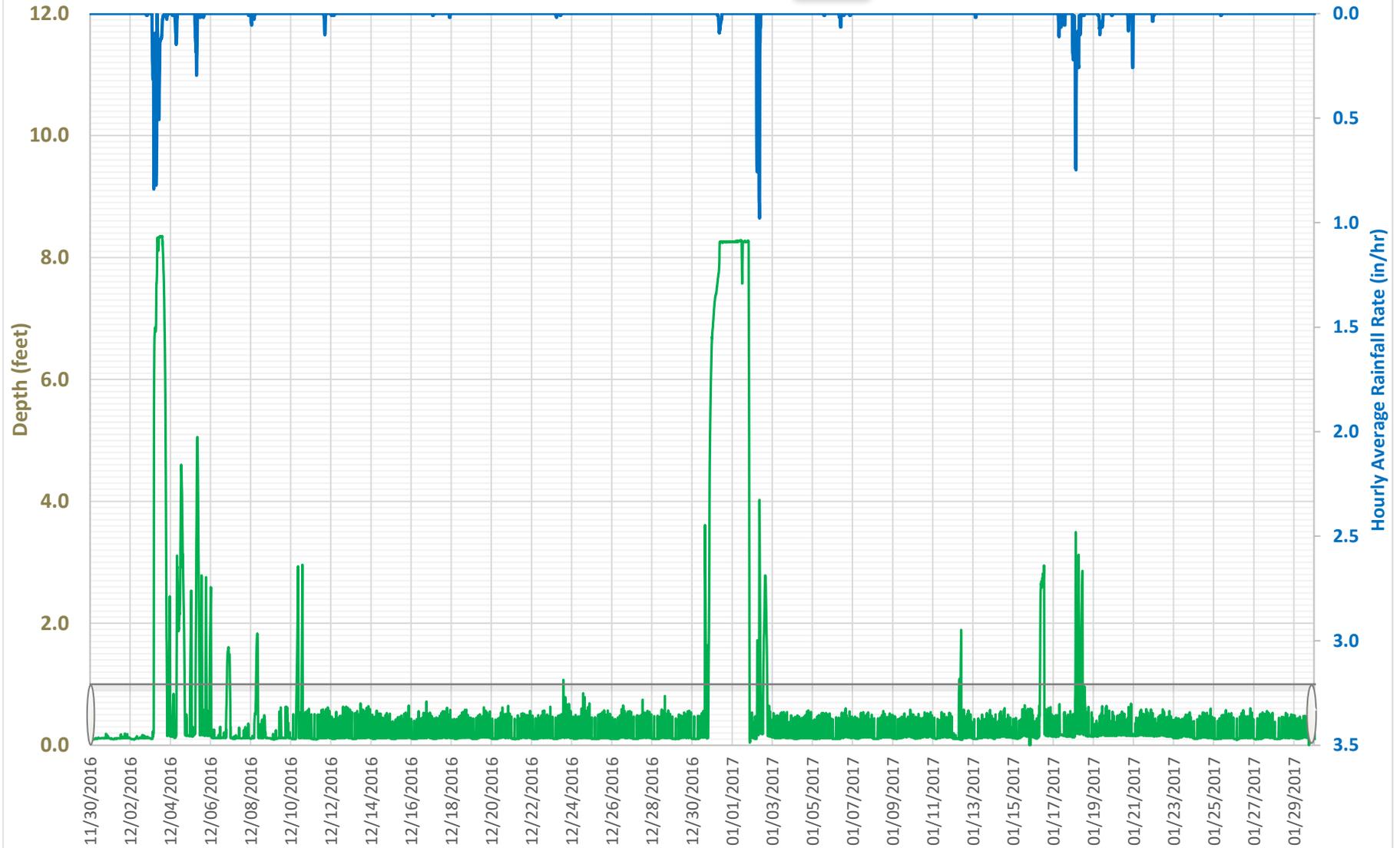


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data

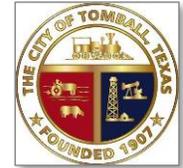


Recorded Depth of Flow

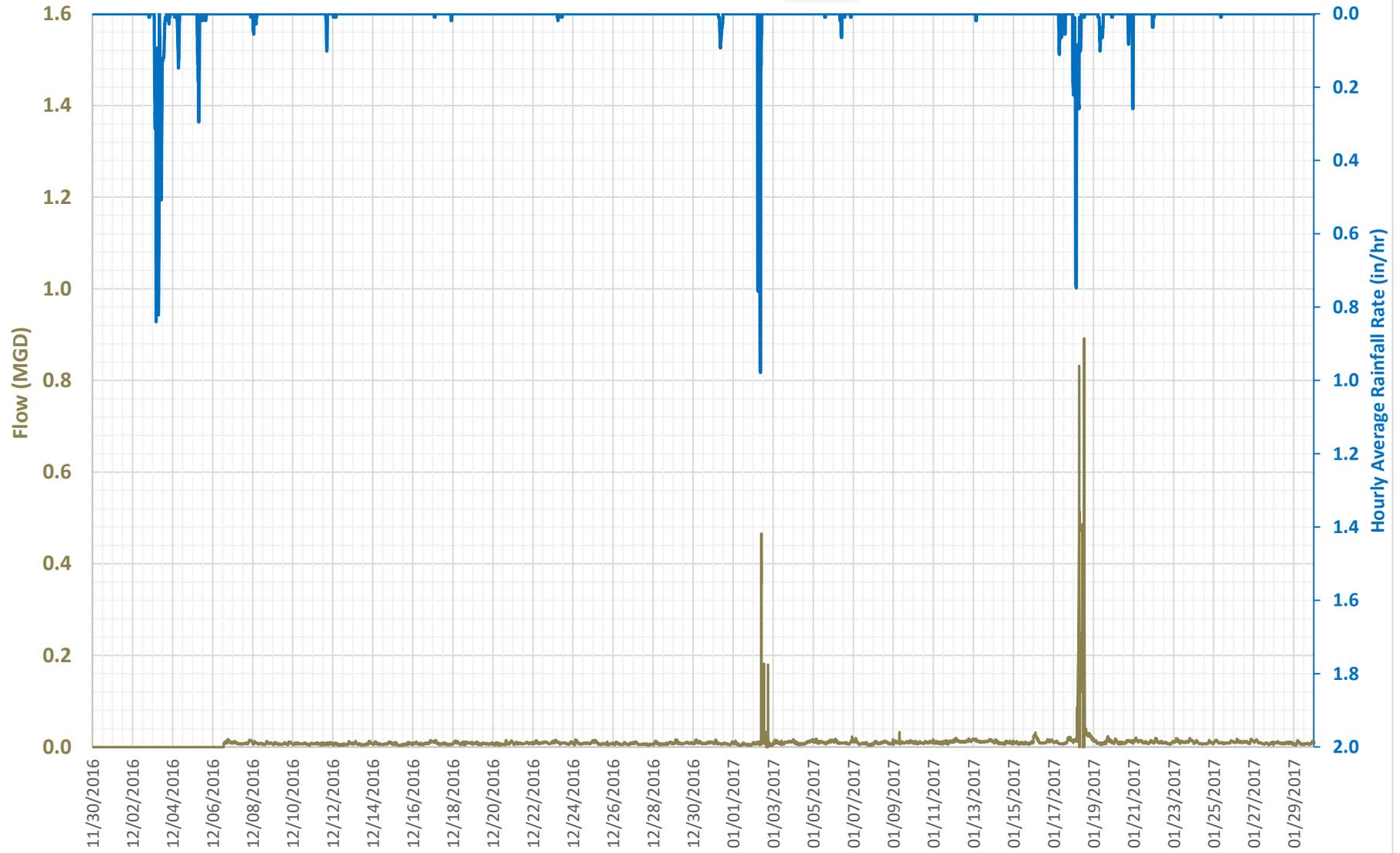
Flow Monitor ID: **N-05**



City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data
Flow Monitor ID: **S-01**



Recorded Flow Rate

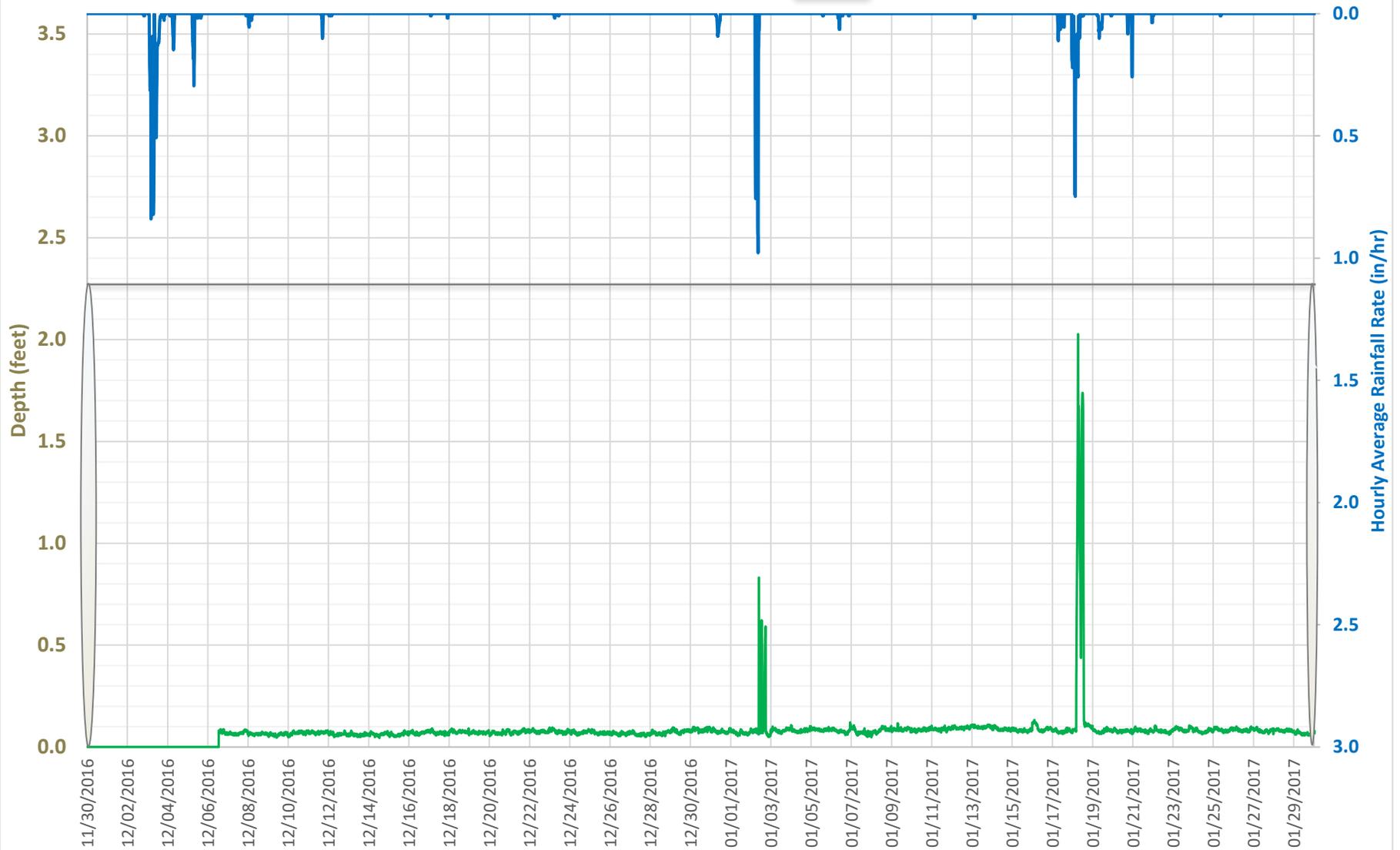


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Depth of Flow

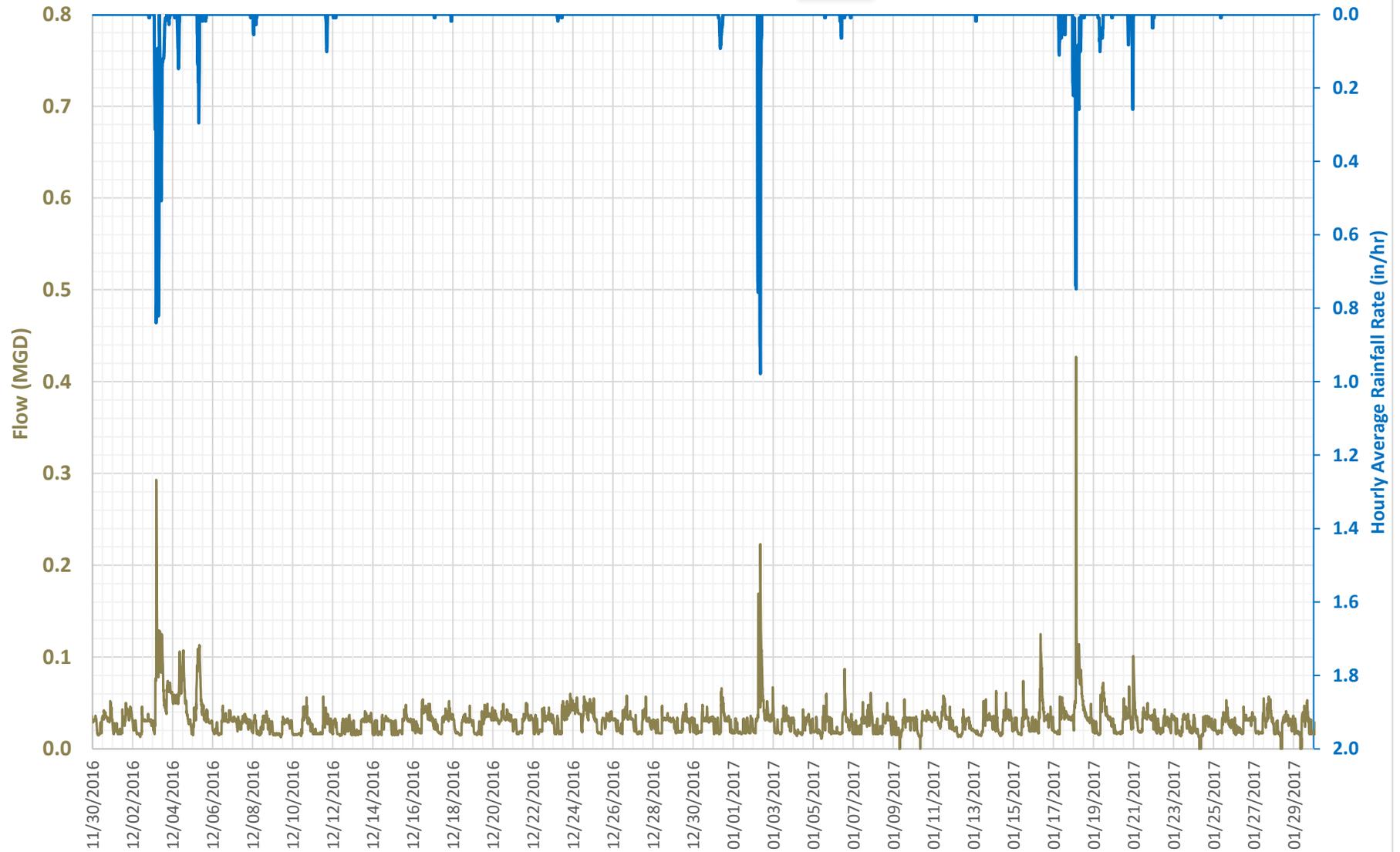
Flow Monitor ID: **S-01**



City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data
Flow Monitor ID: **S-02**



Recorded Flow Rate

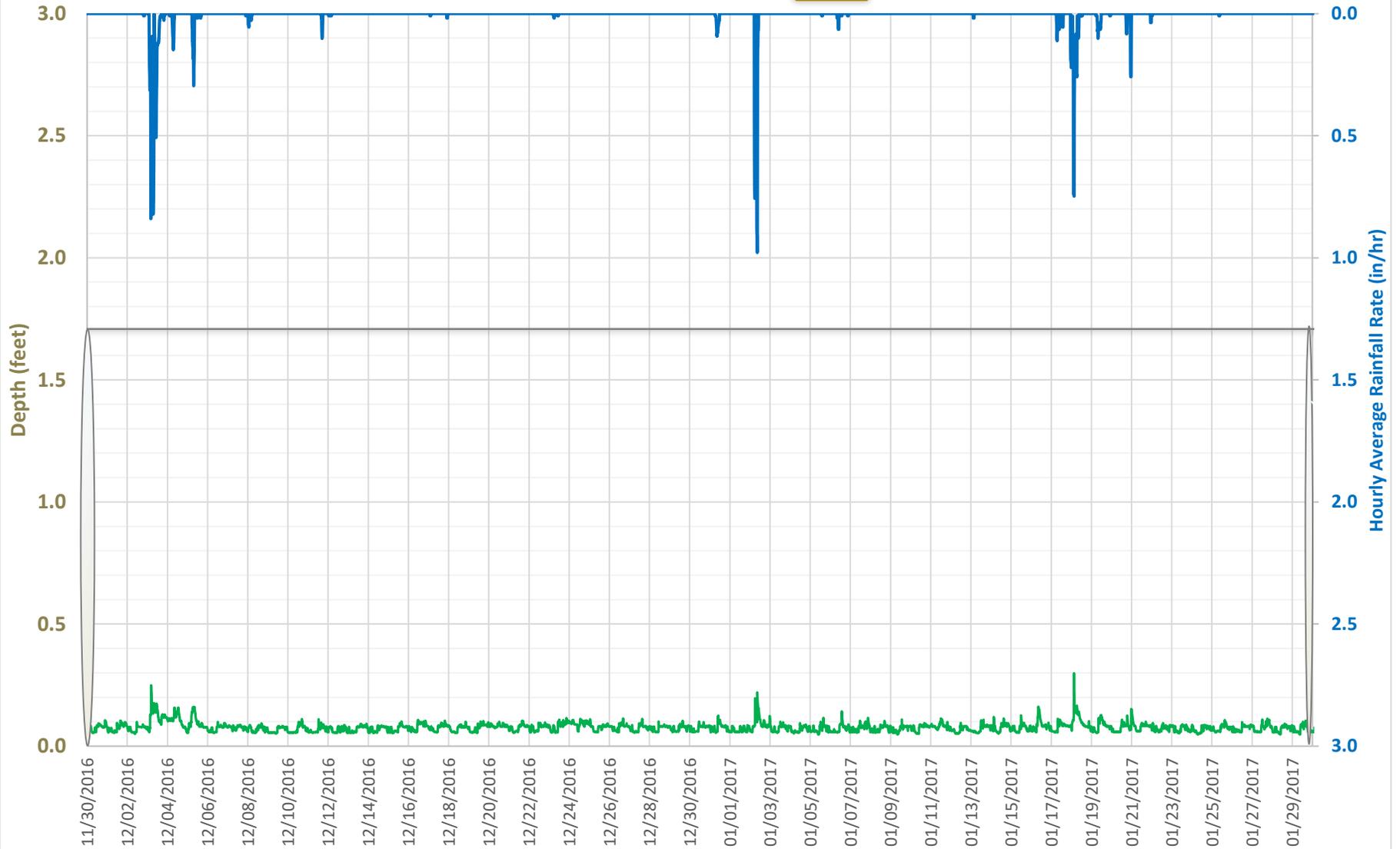


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Depth of Flow

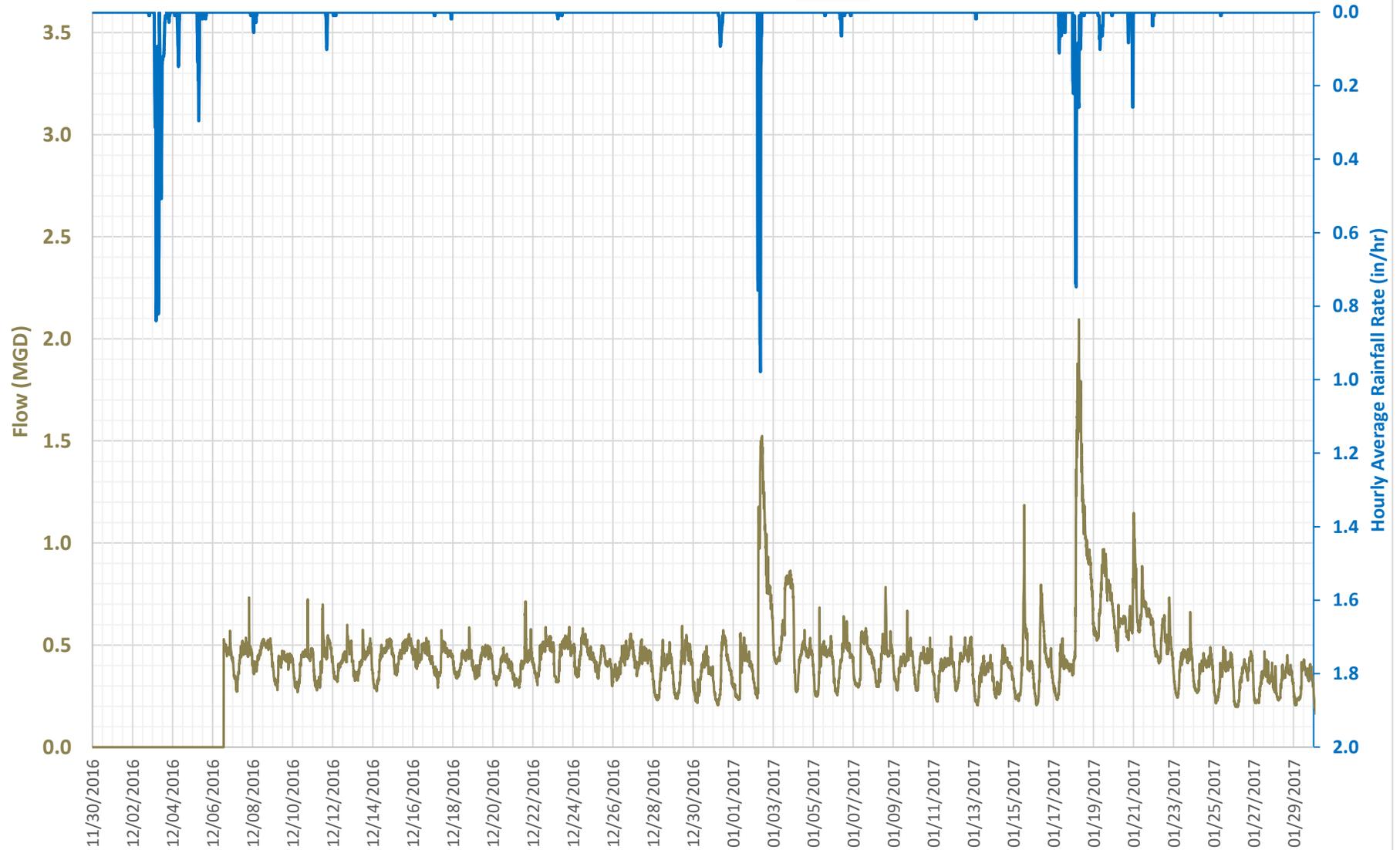
Flow Monitor ID: **S-02**



City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data
Flow Monitor ID: **S-03**



Recorded Flow Rate

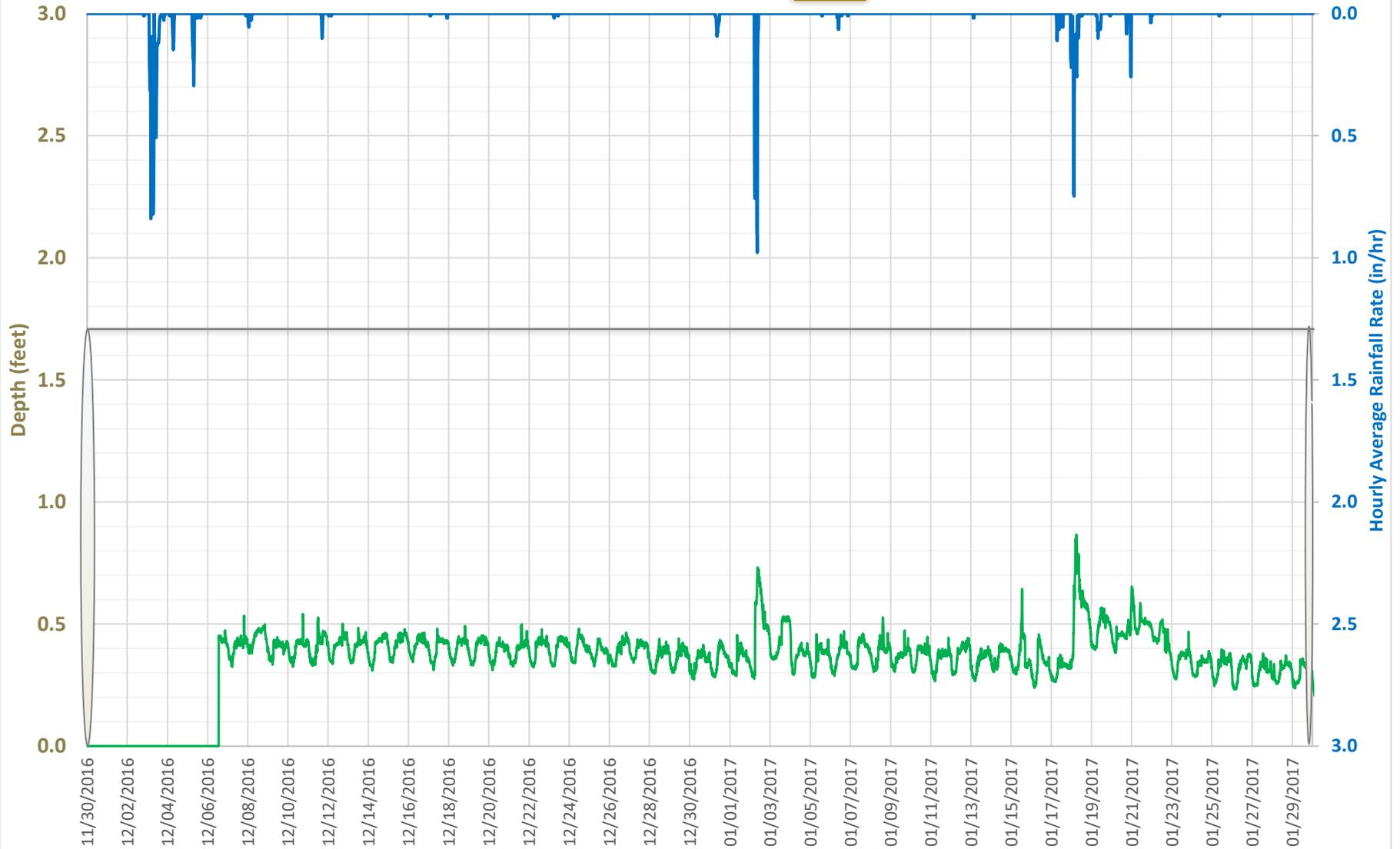


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Depth of Flow

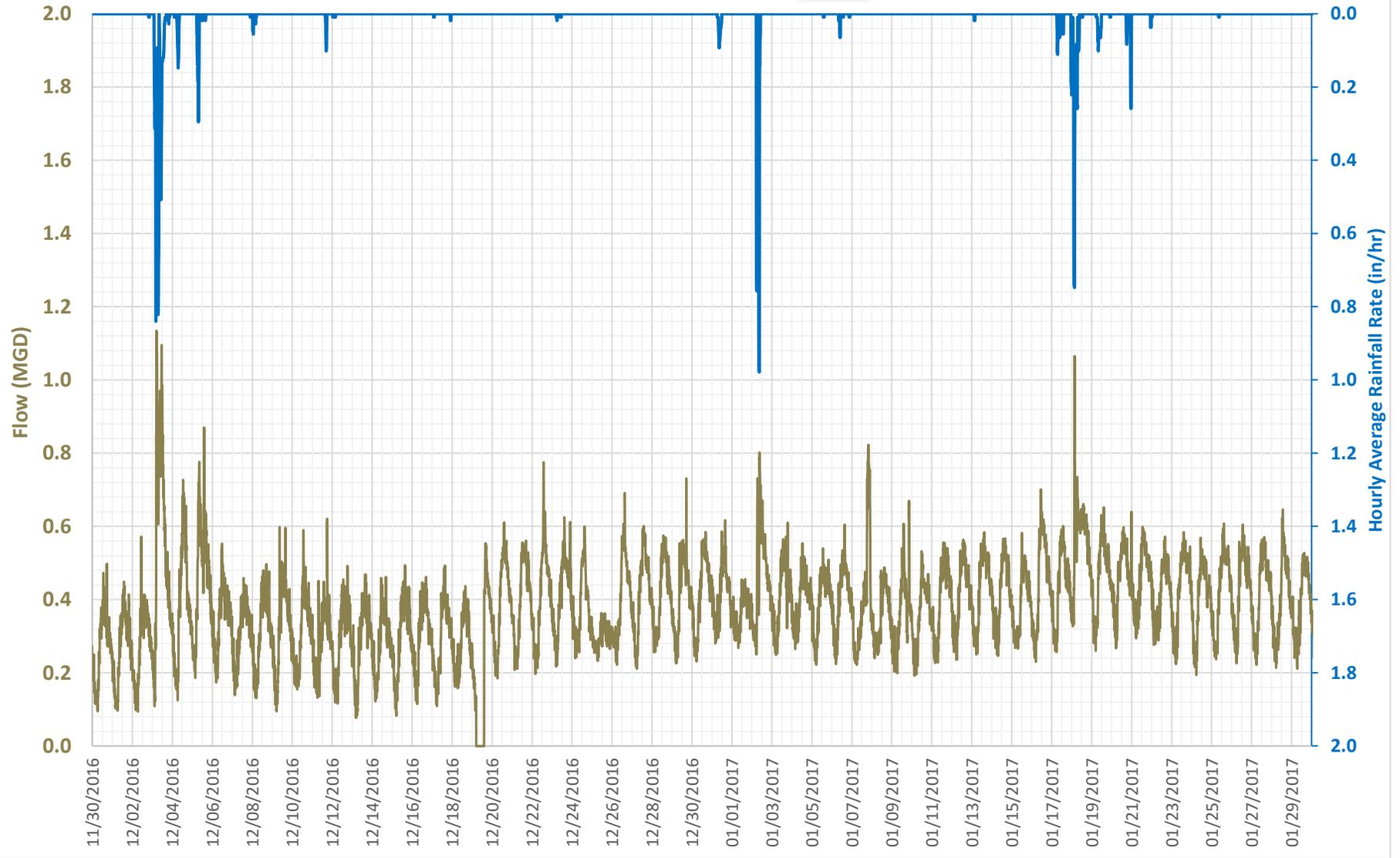
Flow Monitor ID: **S-03**



City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data
Flow Monitor ID: **S-04**



Recorded Flow Rate



City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Depth of Flow

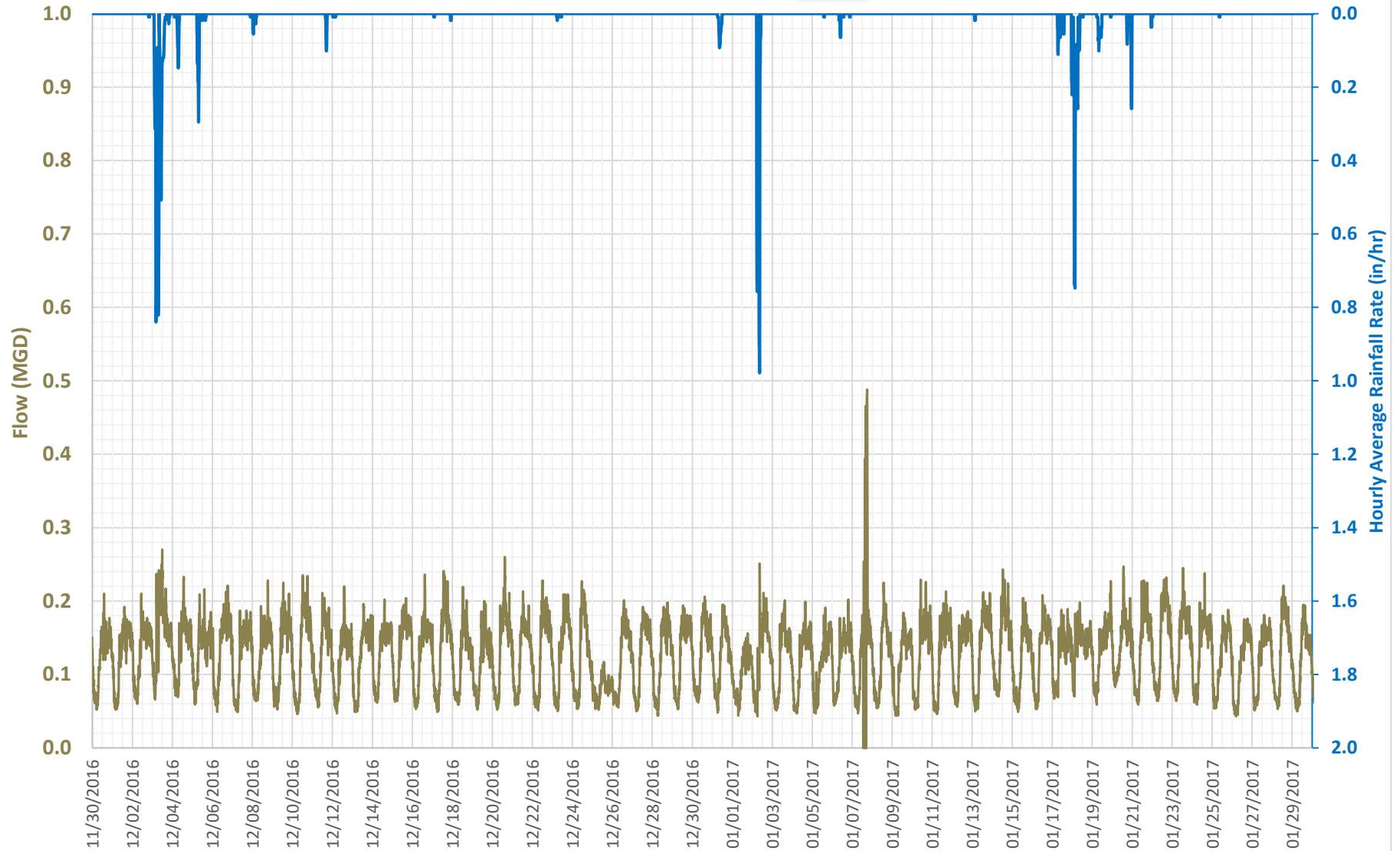
Flow Monitor ID: **S-04**



City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data
Flow Monitor ID: **S-05**



Recorded Flow Rate

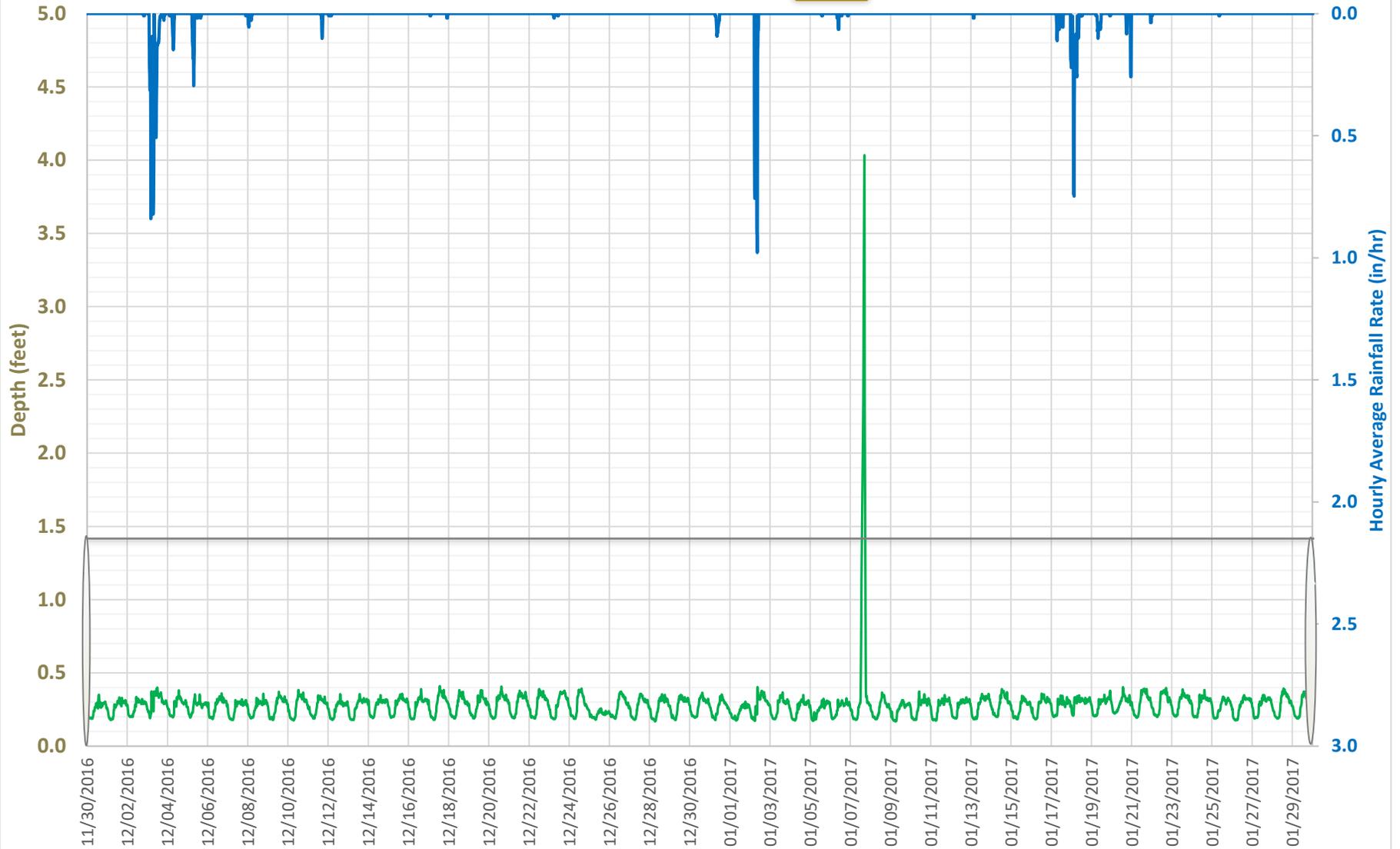


City of Tomball
Wastewater Master Plan
Flow Monitor & Rain Gauge Data



Recorded Depth of Flow

Flow Monitor ID: **S-05**

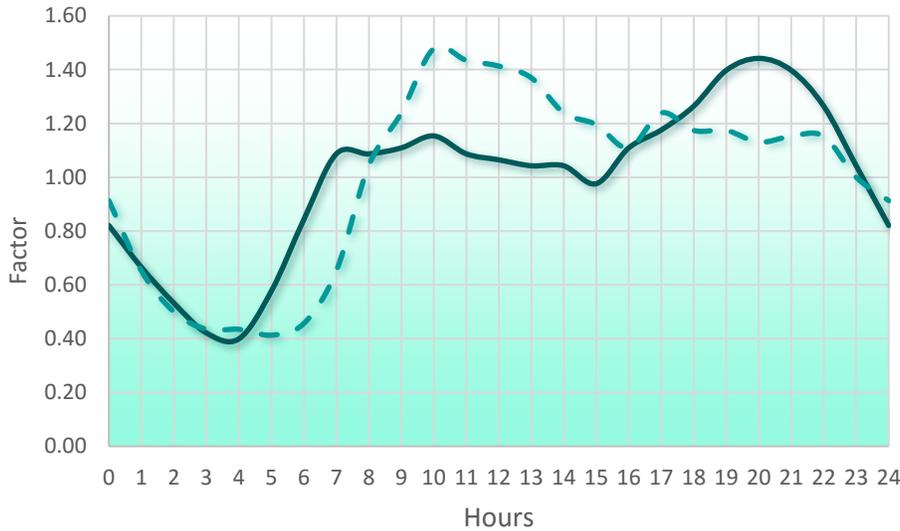


APPENDIX E
Wastewater Diurnal Patterns

City of Tomball Wastewater Master Plan Flow Monitor Diurnal Patterns



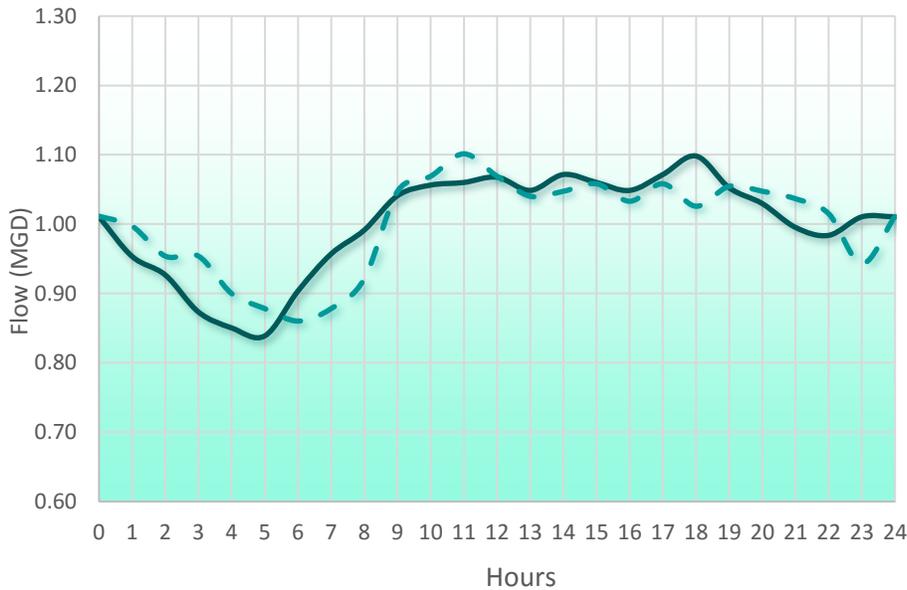
Flow Monitor: N-01



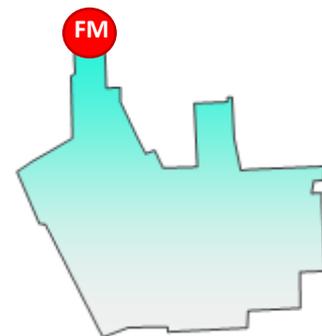
Average Dry Flow
0.045 MGD



Flow Monitor: N-02



Average Dry Flow
0.262 MGD

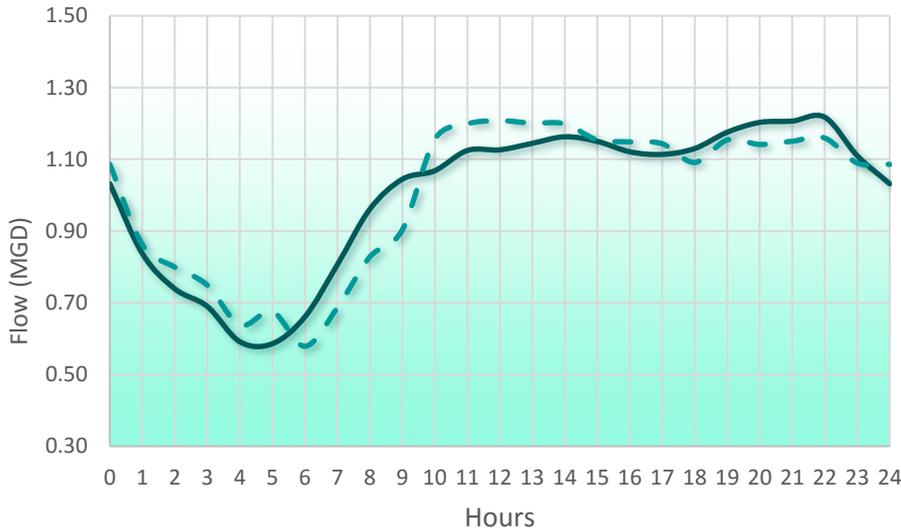


Weekday Diurnal
 Weekend Diurnal
 FM Flow Monitor Location

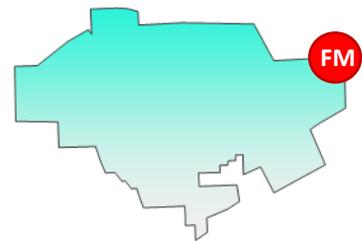
**City of Tomball
Wastewater Master Plan
Flow Monitor Diurnal Patterns**



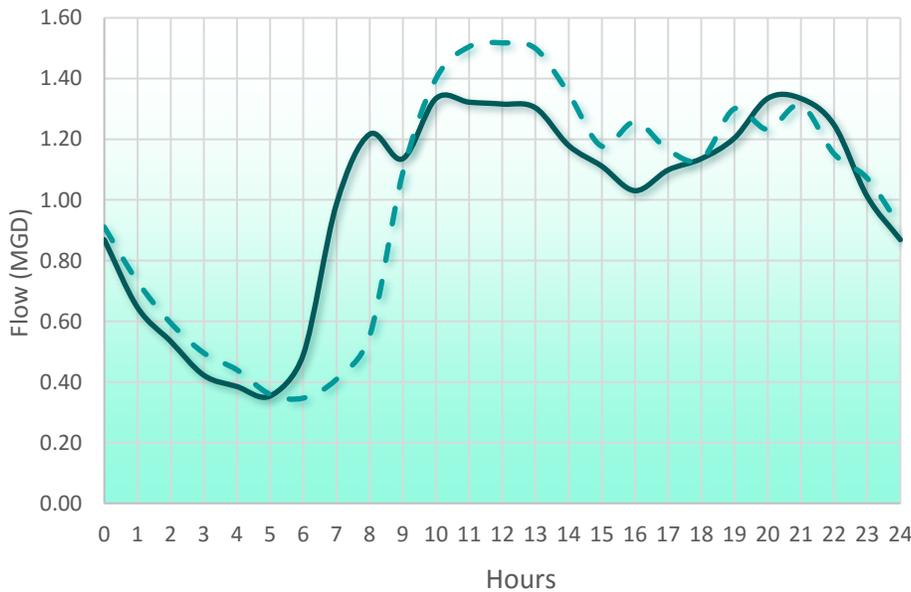
Flow Monitor: N-03



Average Dry Flow
0.545 MGD



Flow Monitor: N-04



Average Dry Flow
0.163 MGD

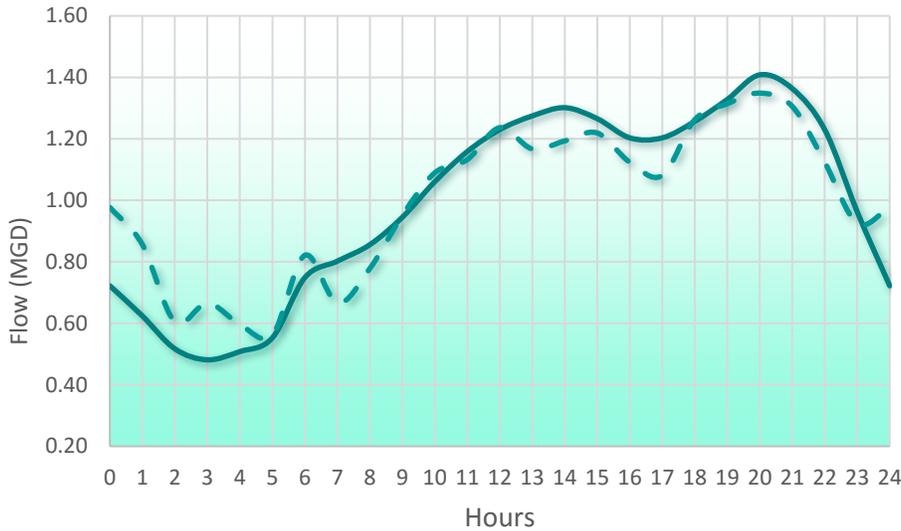


— Weekday Diurnal - - - Weekend Diurnal **FM** Flow Monitor Location

**City of Tomball
Wastewater Master Plan
Flow Monitor Diurnal Patterns**



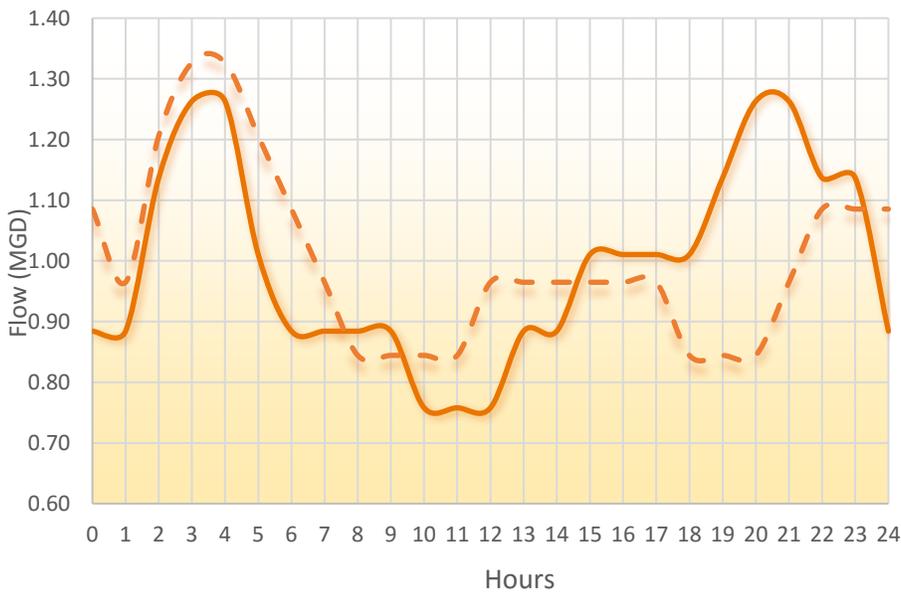
Flow Monitor: N-05



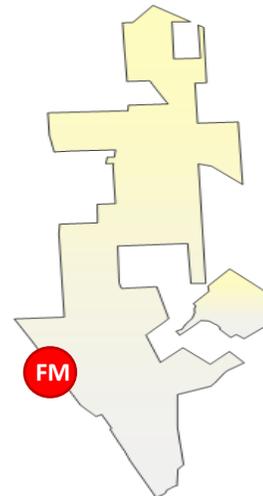
Average Dry Flow
0.114 MGD



Flow Monitor: S-01



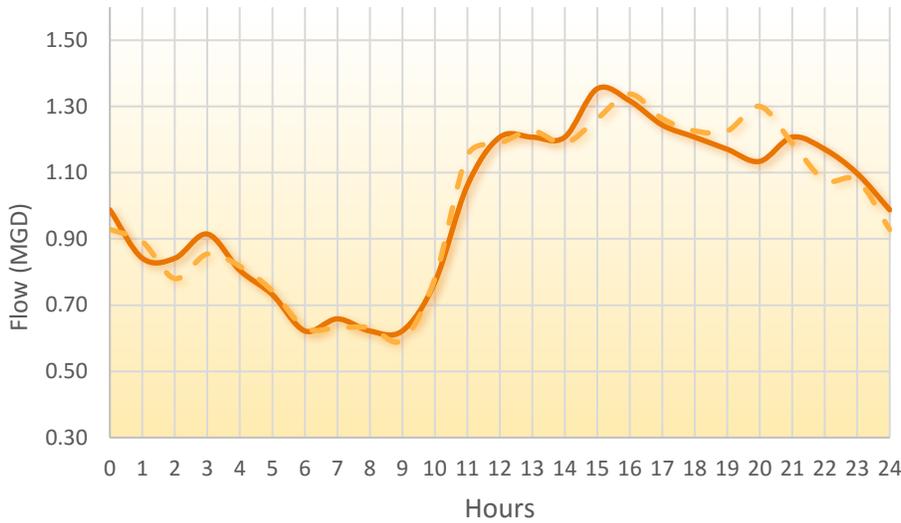
Average Dry Flow
0.008 MGD



**City of Tomball
Wastewater Master Plan
Flow Monitor Diurnal Patterns**



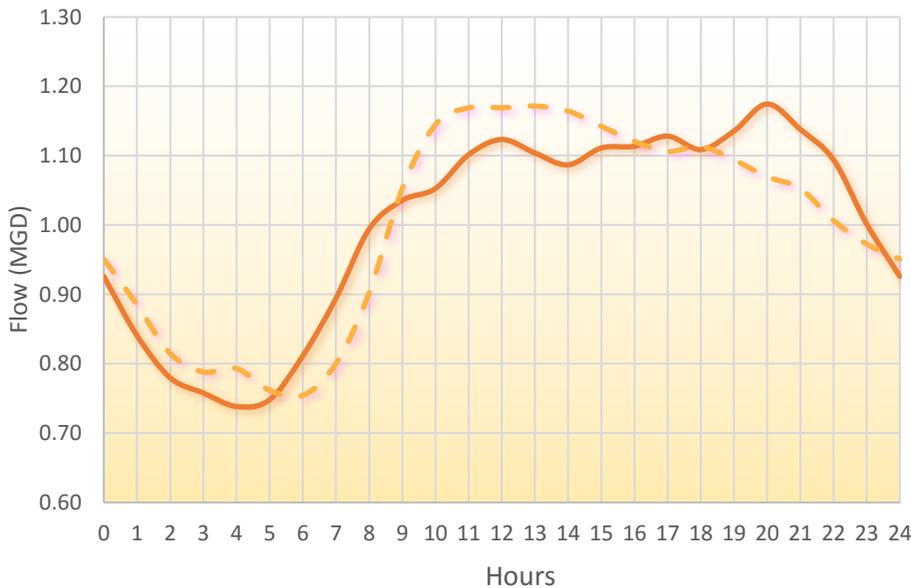
Flow Monitor: S-02



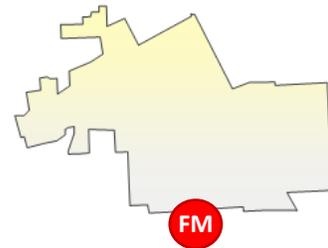
Average Dry Flow
0.027 MGD



Flow Monitor: S-03



Average Dry Flow
0.410 MGD

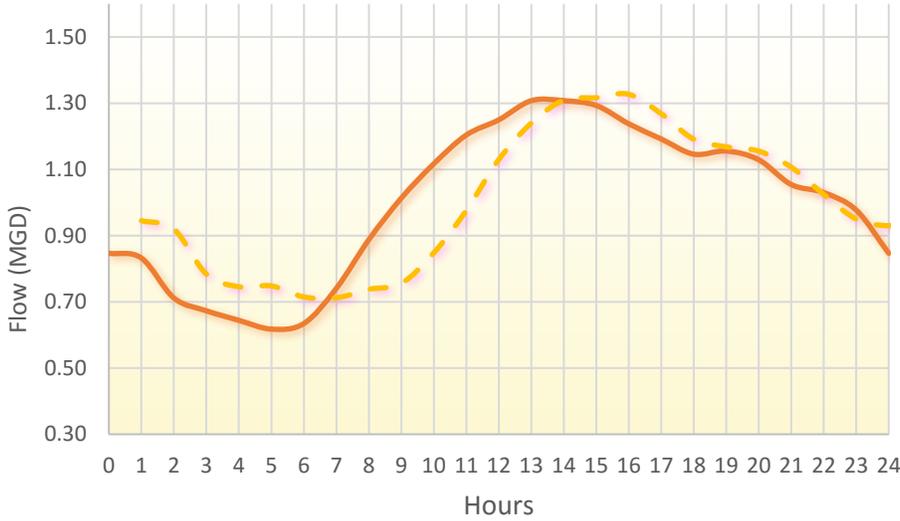


Weekday Diurnal
 Weekend Diurnal
 FM Flow Monitor Location

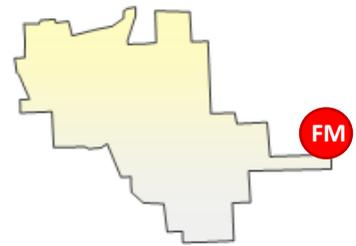
**City of Tomball
Wastewater Master Plan
Flow Monitor Diurnal Patterns**



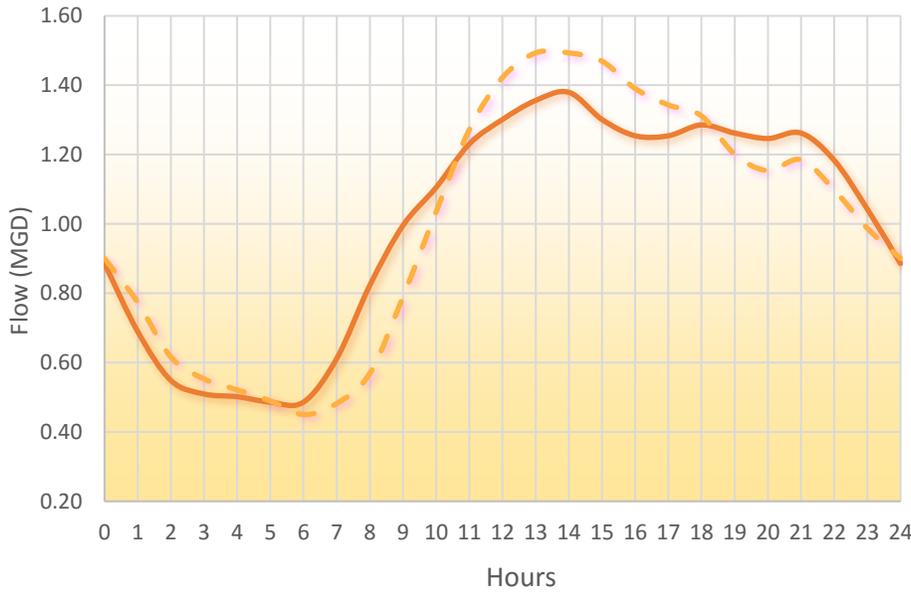
Flow Monitor: S-04



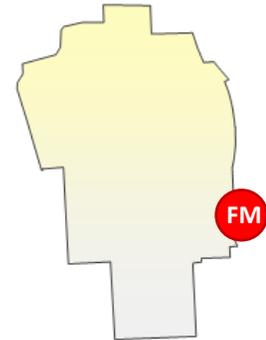
Average Dry Flow
0.414 MGD



Flow Monitor: S-05



Average Dry Flow
0.128 MGD



Weekday Diurnal
 Weekend Diurnal
 FM Flow Monitor Location

APPENDIX F
Collection System Field Data Forms

Glen Williams

From: John Escamilla
Sent: Thursday, January 26, 2017 1:19 PM
To: Glen Williams
Subject: FW: Wastewater System Measure Downs
Attachments: Wastewater System Measure Down Locations - 01-26-2017.pdf; Manhole Measure Down Sheets - 01-26-2017.pdf

Glen,

This will be a good little project for James & Tracy next week don't you think?

JE

From: Kendall Ryan [mailto:Kendall.Ryan@freese.com]
Sent: Thursday, January 26, 2017 12:55 PM
To: John Escamilla; Glen Williams
Cc: Richard Weatherly; Ishita Rahman; Meagan Mageo
Subject: Wastewater System Measure Downs

John/Glen,

Great to see you on Tuesday, and thanks again for all the info. on the wastewater system connectivity.

As we mentioned, there were a few places where we'd like to verify line configuration and depths at manholes. We have identified 6 manholes on the *attached* figure. We have also *attached* a form for each location that your crew can fill out. There is a Manhole ID on each form that matches the labels on the map. The rim height above ground and the depth from rim for the incoming line(s) and outgoing line are the most important pieces of information needed for the model.

We've also identified 3 lift stations where we don't know the wet well depths:

- Sherwood - Total depth = 18' 8" North inlet = 14' 8 1/2" South inlet = 7'
- Snook Lane - Total depth = 19' 9" - (North inlet = 46") South inlet = 58"
- FM 2920 and Park Rd. - Total depth = 20' West inlet = 15' 7 1/2" East inlet = 14' 11"

If you could tell us the depth of the wet well and the depth to the incoming gravity flow line, that would be really helpful.

Thanks, and please let us know if you have any questions! I'm available on my cell (210) 232-1480.



MANHOLE MEASURE DOWN COLLECTION FOR THE CITY OF TOMBALL, TEXAS

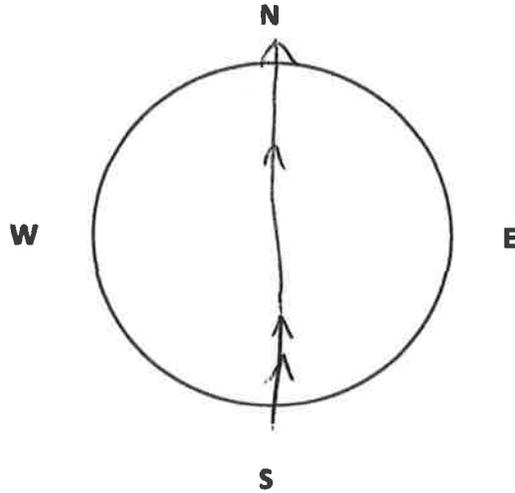
MANHOLE ID: MH-316

CREW LEADER: Tracy

DATE OF COLLECTION: 2-1-17

TIME OF COLLECTION: 9:45am

MANHOLE SKETCH



PLEASE SKETCH INCOMING AND OUTGOING LINES

MANHOLE DETAILS

MANHOLE DIAMETER: 5'

RIM HEIGHT ABOVE GROUND: 1"

MANHOLE CONSTRUCTION MATERIAL:

CONCRETE BRICK FIBERGLASS

UNKNOWN OTHER: _____

MANHOLE CONDITION:

POOR FAIR GOOD

INCOMING / OUTGOING PIPES

DIAMETER (INCHES)	FLOW DIRECTION	DEPTH FROM RIM (FEET)	COMMENTS
2 12"	IN	8' 10"	
	IN		
	IN		
3 12"	OUT	10' 3"	
	OUT		



MANHOLE MEASURE DOWN SHEET



MANHOLE MEASURE DOWN COLLECTION FOR THE CITY OF TOMBALL, TEXAS

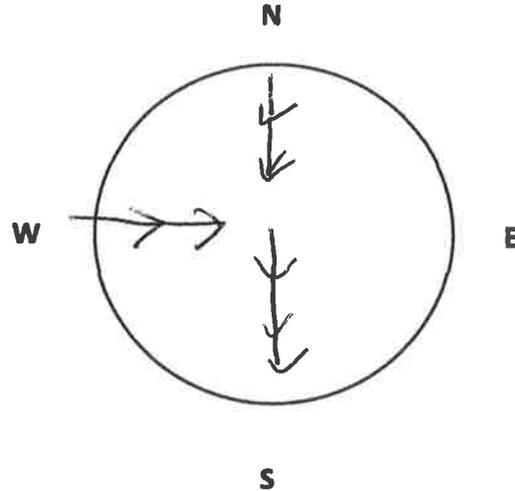
MANHOLE ID: MH-632

MANHOLE SKETCH

CREW LEADER: Tracy

DATE OF COLLECTION: 1-31-17

TIME OF COLLECTION: 3:40pm



MANHOLE DETAILS

MANHOLE DIAMETER: 4'

RIM HEIGHT ABOVE GROUND: 12"

MANHOLE CONSTRUCTION MATERIAL:

CONCRETE BRICK FIBERGLASS

UNKNOWN OTHER: _____

MANHOLE CONDITION:

POOR FAIR GOOD

PLEASE SKETCH INCOMING AND OUTGOING LINES

INCOMING / OUTGOING PIPES

DIAMETER (INCHES)	FLOW DIRECTION	DEPTH FROM RIM (FEET)	COMMENTS
N 10"	IN	5'10"	
W 6"	IN	5'10"	
	IN		
10"	OUT	5'11"	
	OUT		



MANHOLE MEASURE DOWN COLLECTION FOR THE CITY OF TOMBALL, TEXAS

MANHOLE ID: MH-213

CREW LEADER: Tracy

DATE OF COLLECTION: 1-31-17

TIME OF COLLECTION: 2:48pm

MANHOLE SKETCH

PLEASE SKETCH INCOMING AND OUTGOING LINES

MANHOLE DETAILS

MANHOLE DIAMETER: 4'

RIM HEIGHT ABOVE GROUND: level

MANHOLE CONSTRUCTION MATERIAL:

CONCRETE BRICK FIBERGLASS

UNKNOWN OTHER: _____

MANHOLE CONDITION:

POOR FAIR GOOD

INCOMING / OUTGOING PIPES

DIAMETER (INCHES)	FLOW DIRECTION	DEPTH FROM RIM (FEET)	COMMENTS
15"	IN	9'	
15"	IN	9'3"	
	IN		
20"	OUT	8'8"	
	OUT		



MANHOLE MEASURE DOWN SHEET



MANHOLE MEASURE DOWN COLLECTION FOR THE CITY OF TOMBALL, TEXAS

MANHOLE ID: MH-146

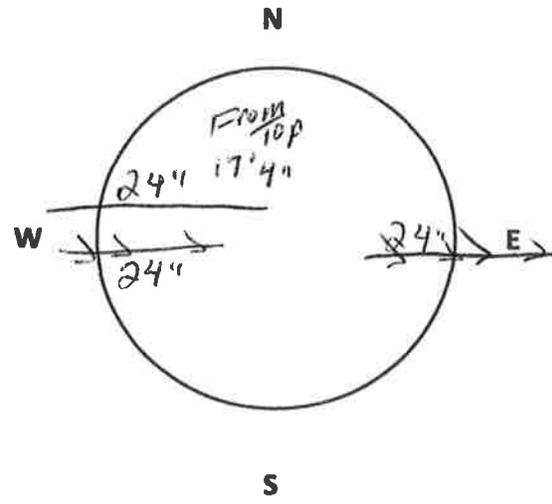
CREW LEADER: Tracy

DATE OF COLLECTION: 1-31-17

TIME OF COLLECTION: 11:03

MANHOLE SKETCH

Appears to be 2 lines incoming



MANHOLE DETAILS

MANHOLE DIAMETER: 48"

RIM HEIGHT ABOVE GROUND: 36"

MANHOLE CONSTRUCTION MATERIAL:

CONCRETE BRICK FIBERGLASS

UNKNOWN OTHER: _____

MANHOLE CONDITION:

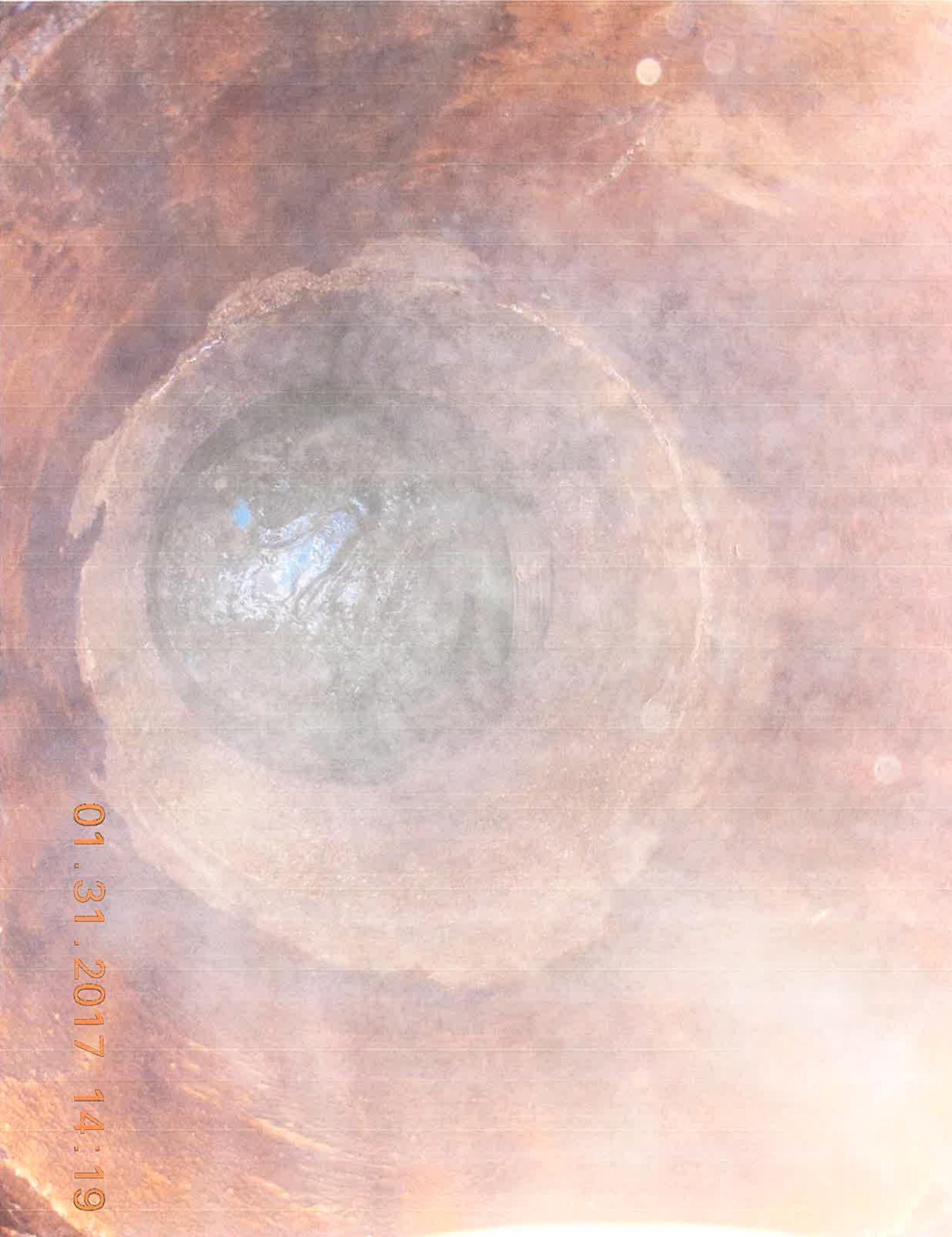
POOR FAIR GOOD

PLEASE SKETCH INCOMING AND OUTGOING LINES

INCOMING / OUTGOING PIPES

DIAMETER (INCHES)	FLOW DIRECTION	DEPTH FROM RIM (FEET)	COMMENTS
24"	IN	17'4"	(outlet under water)
24"	IN	18'	water seeping at seams
	IN		
24"	OUT	18'	
	OUT		

01.31.2017 14:19





MANHOLE MEASURE DOWN COLLECTION FOR THE CITY OF TOMBALL, TEXAS

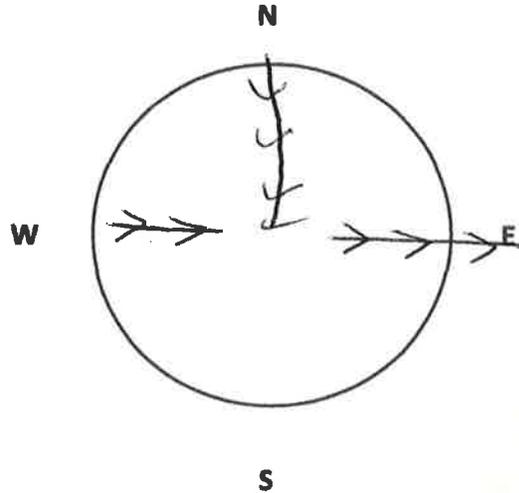
MANHOLE ID: MH-920

CREW LEADER: TRACY

DATE OF COLLECTION: 1-31-17

TIME OF COLLECTION: 3:02 pm

MANHOLE SKETCH



PLEASE SKETCH INCOMING AND OUTGOING LINES

MANHOLE DETAILS

MANHOLE DIAMETER: 5'

RIM HEIGHT ABOVE GROUND: 2"

MANHOLE CONSTRUCTION MATERIAL:

CONCRETE BRICK FIBERGLASS

UNKNOWN OTHER: _____

MANHOLE CONDITION:

POOR FAIR GOOD

INCOMING / OUTGOING PIPES

DIAMETER (INCHES)	FLOW DIRECTION	DEPTH FROM RIM (FEET)	COMMENTS
20"	IN	13'4 1/4"	
12"	IN	13'7"	
	IN		
20"	OUT	13'4"	
	OUT		



MANHOLE MEASURE DOWN COLLECTION FOR THE CITY OF TOMBALL, TEXAS

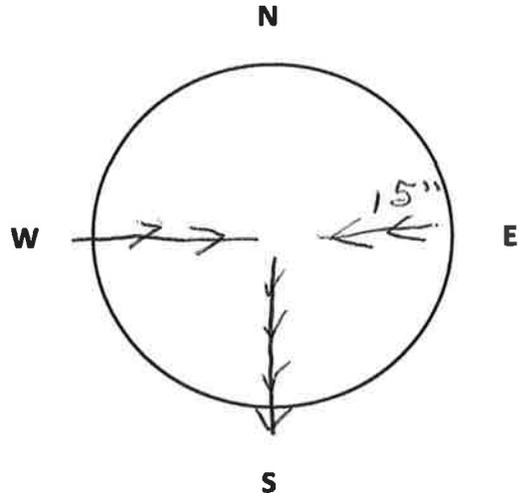
MANHOLE ID: MH-421

CREW LEADER: Tracy

DATE OF COLLECTION: 1-31-17

TIME OF COLLECTION: 1:58pm

MANHOLE SKETCH



MANHOLE DETAILS

MANHOLE DIAMETER: 48"

RIM HEIGHT ABOVE GROUND: 17"

MANHOLE CONSTRUCTION MATERIAL:

CONCRETE BRICK FIBERGLASS

UNKNOWN OTHER: _____

MANHOLE CONDITION:

POOR FAIR GOOD

PLEASE SKETCH INCOMING AND OUTGOING LINES

INCOMING / OUTGOING PIPES

DIAMETER (INCHES)	FLOW DIRECTION	DEPTH FROM RIM (FEET)	COMMENTS
15"	IN	15'3"	Sand
15"	IN	15'4"	
	IN		
15"	OUT	15'2"	
	OUT		

APPENDIX G

Wastewater Model Calibration Results

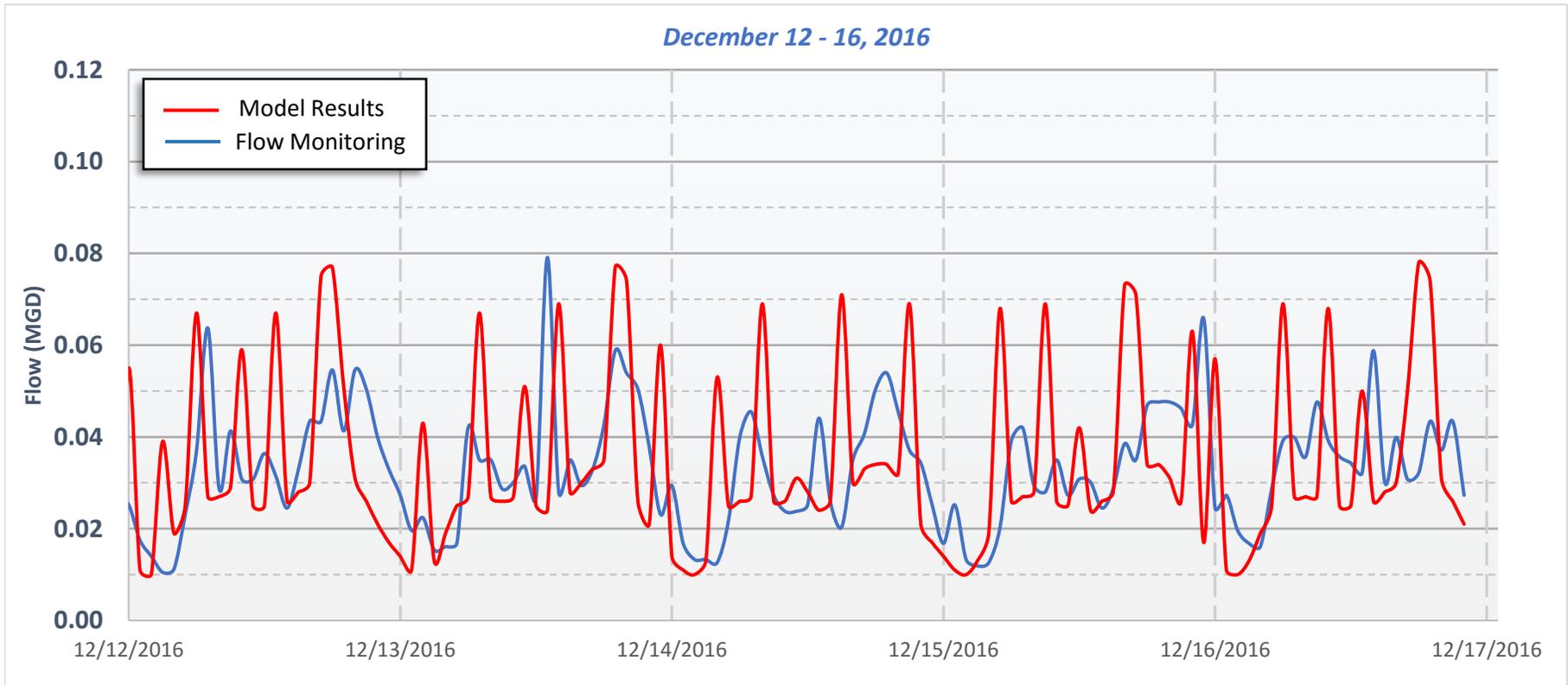
City of Tomball

Wastewater Master Plan

Dry Weather Calibration



Flow Monitor: N-01



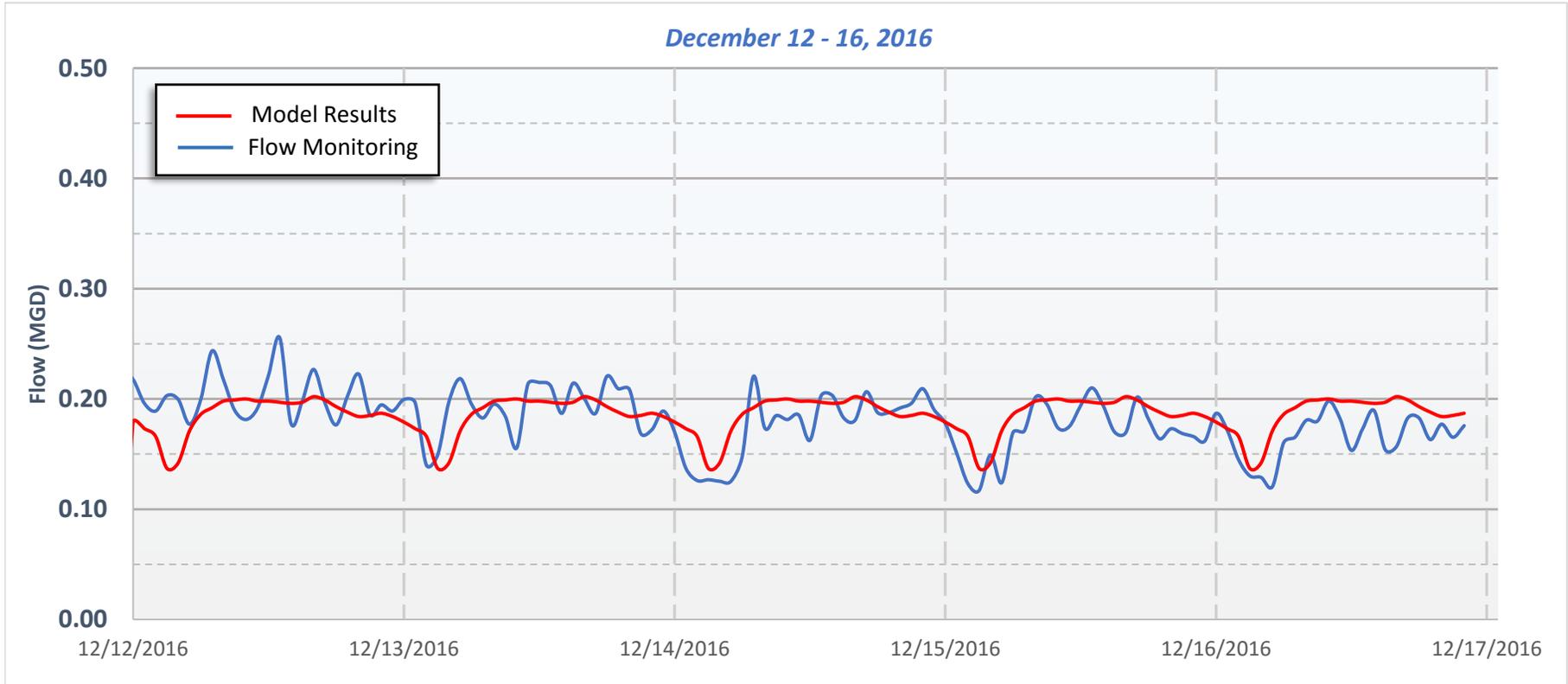
City of Tomball

Wastewater Master Plan

Dry Weather Calibration



Flow Monitor: N-02



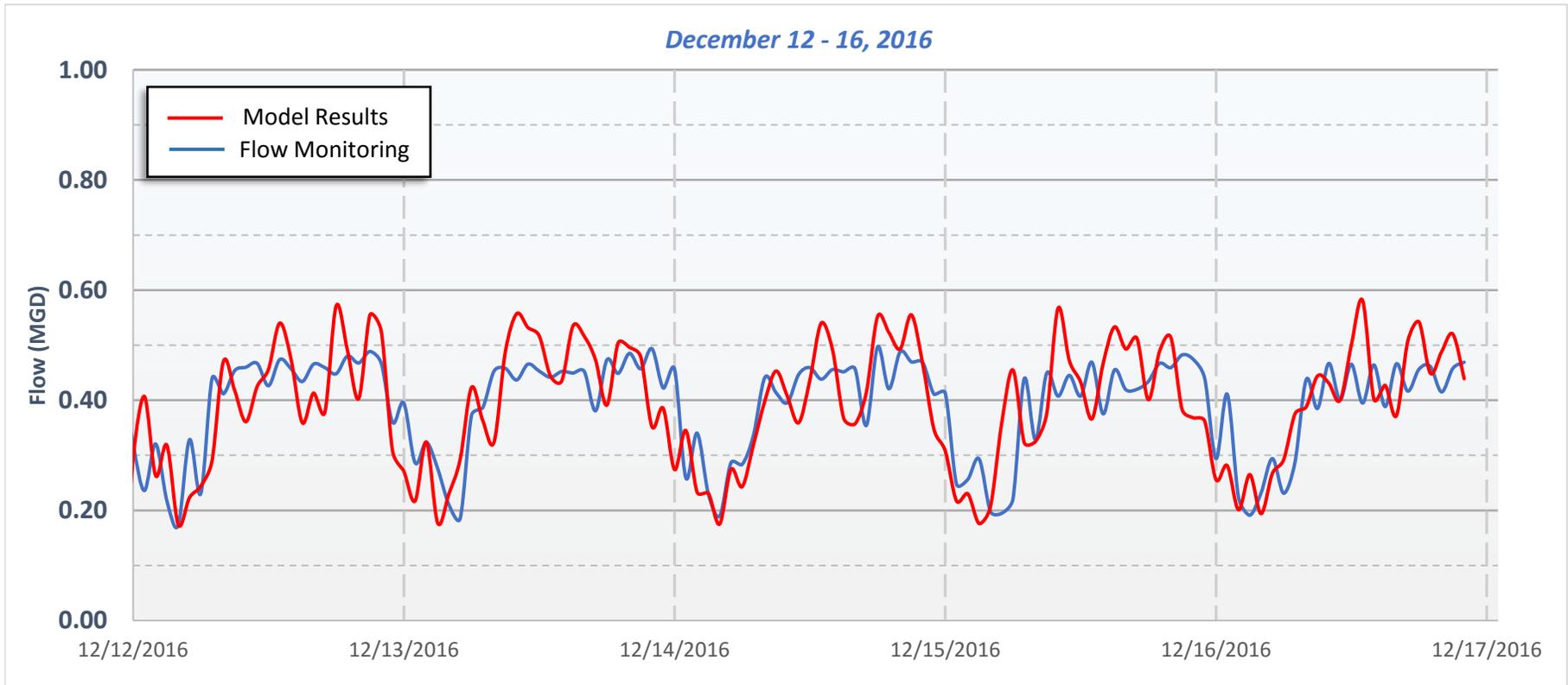
City of Tomball

Wastewater Master Plan

Dry Weather Calibration



Flow Monitor: N-03



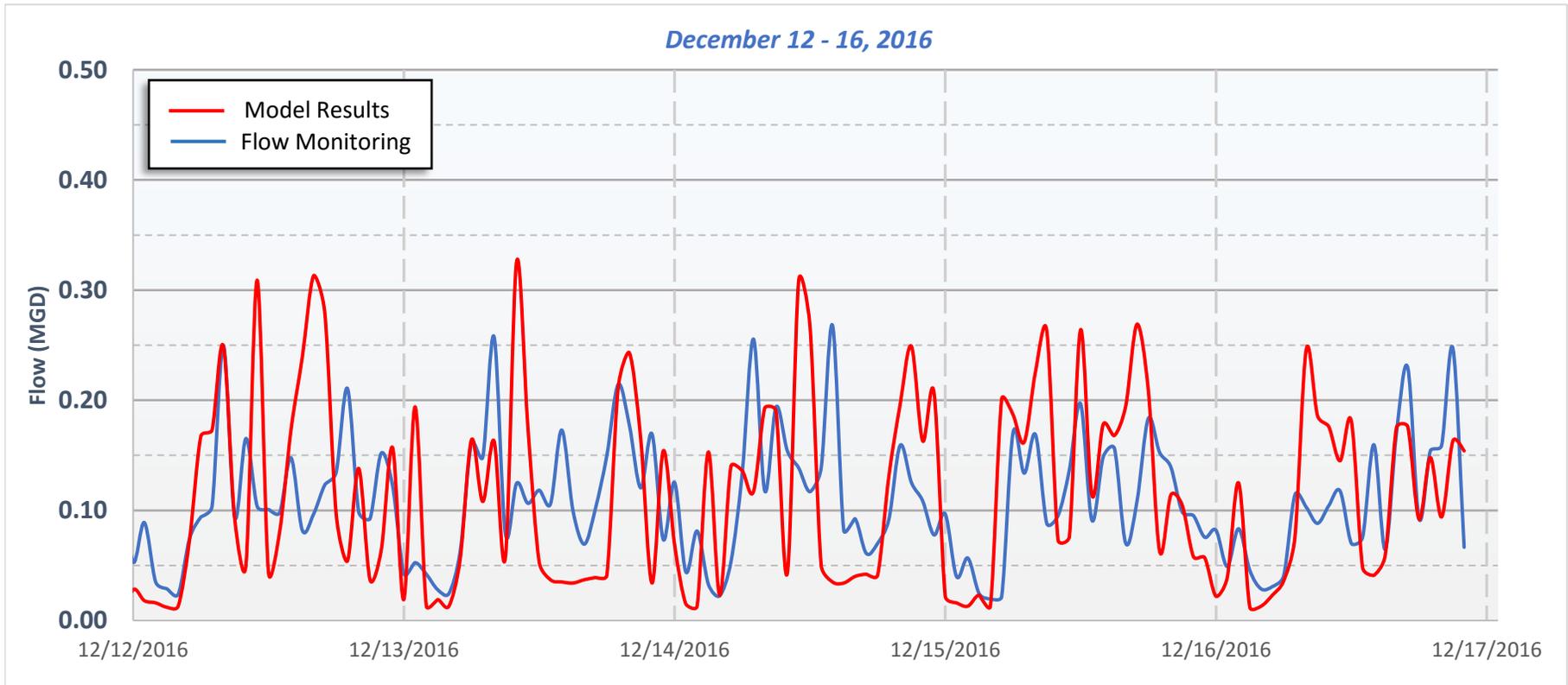
City of Tomball

Wastewater Master Plan

Dry Weather Calibration



Flow Monitor: N-04



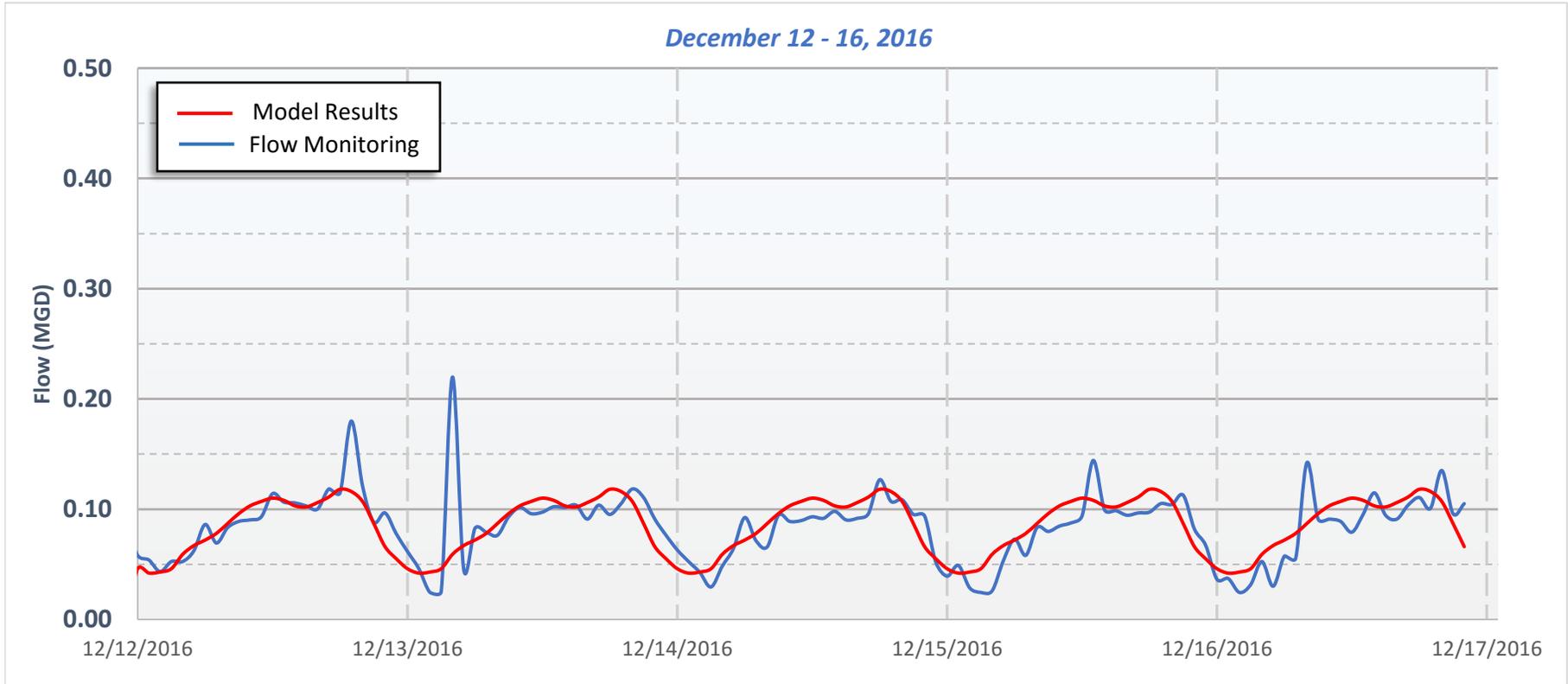
City of Tomball

Wastewater Master Plan

Dry Weather Calibration



Flow Monitor: N-05



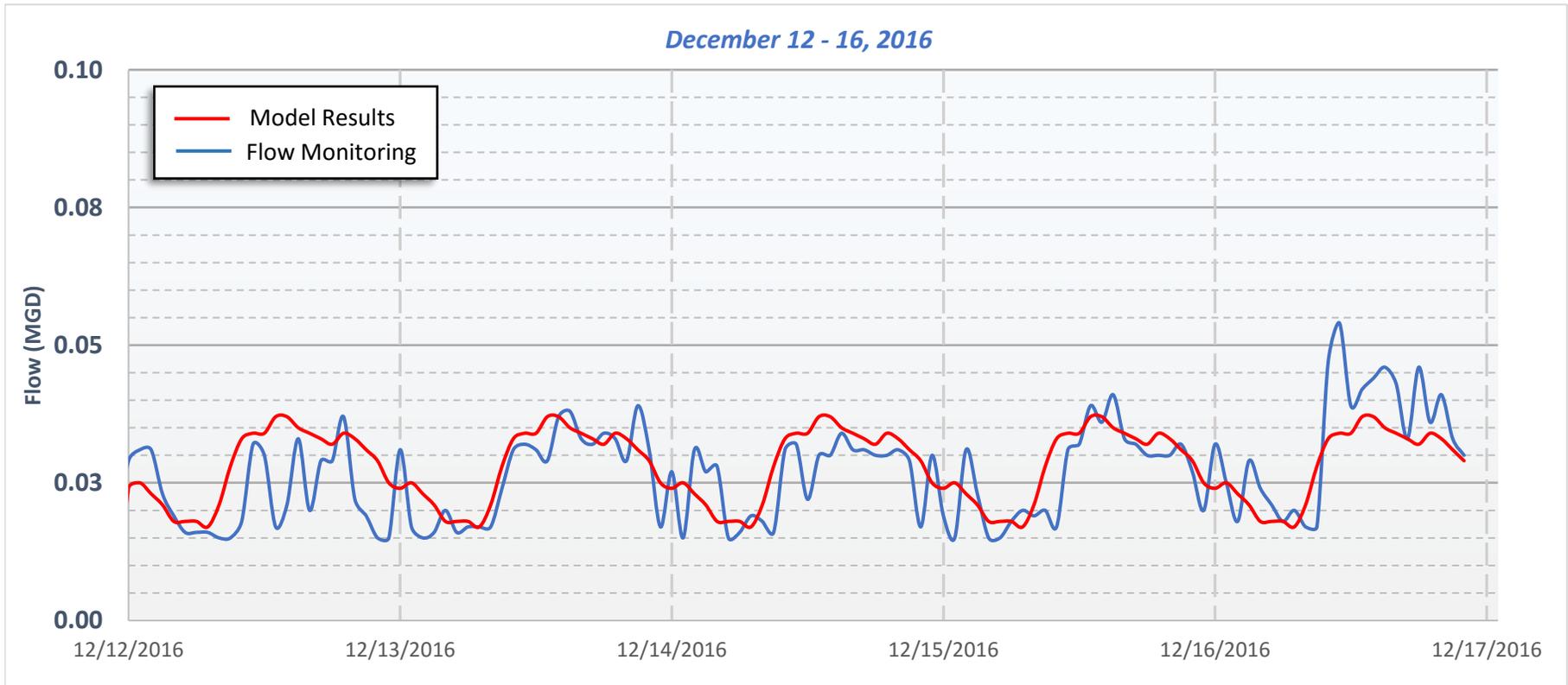
City of Tomball

Wastewater Master Plan

Dry Weather Calibration



Flow Monitor: S-02



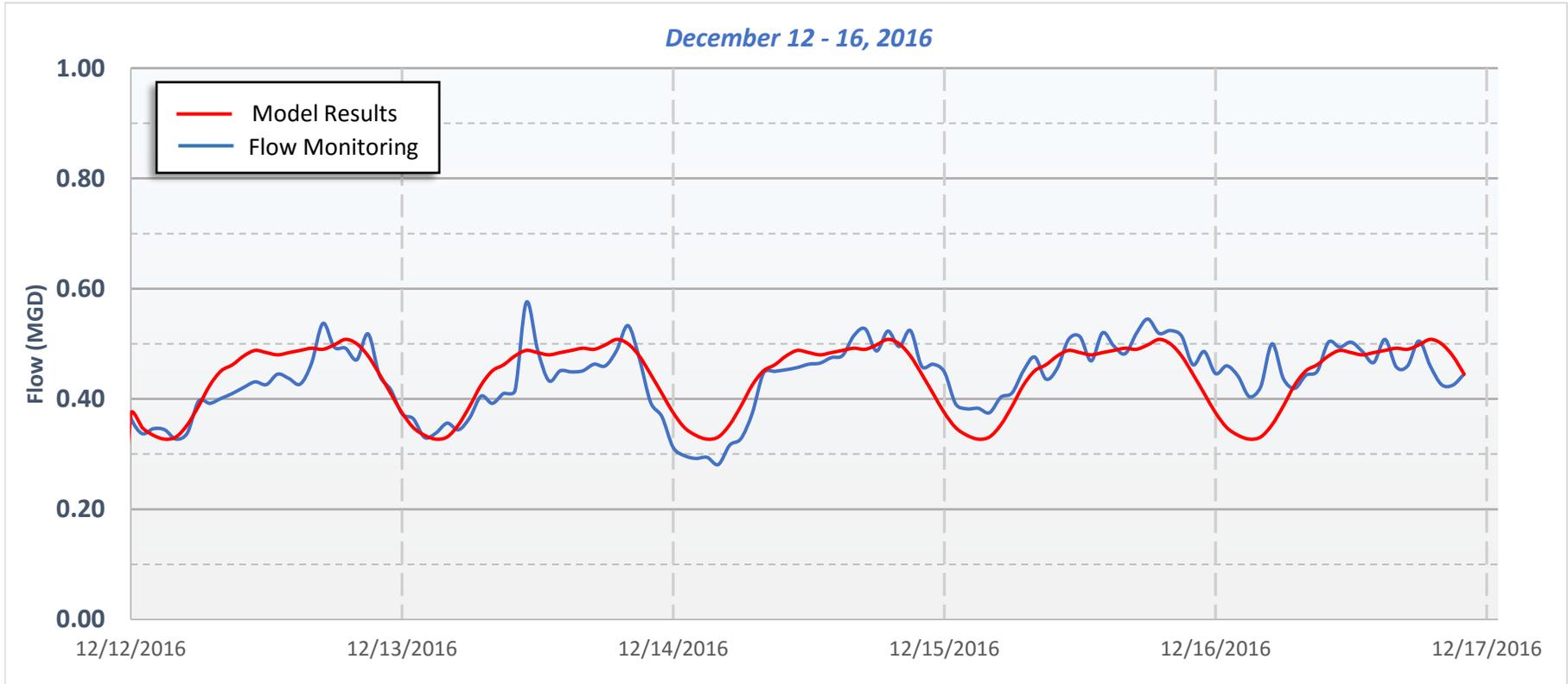
City of Tomball

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Flow Monitor: S-03



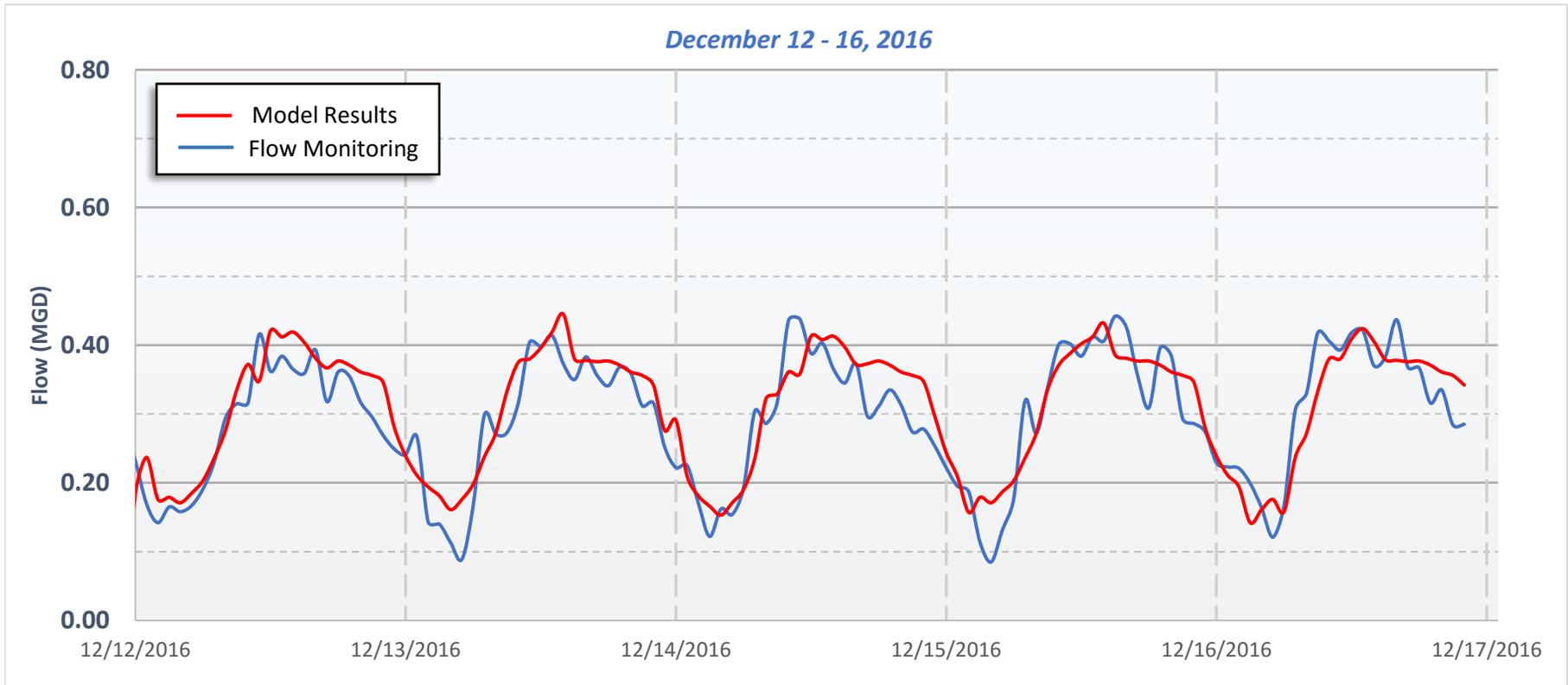
City of Tomball

Wastewater Master Plan

Dry Weather Calibration



Flow Monitor: S-04



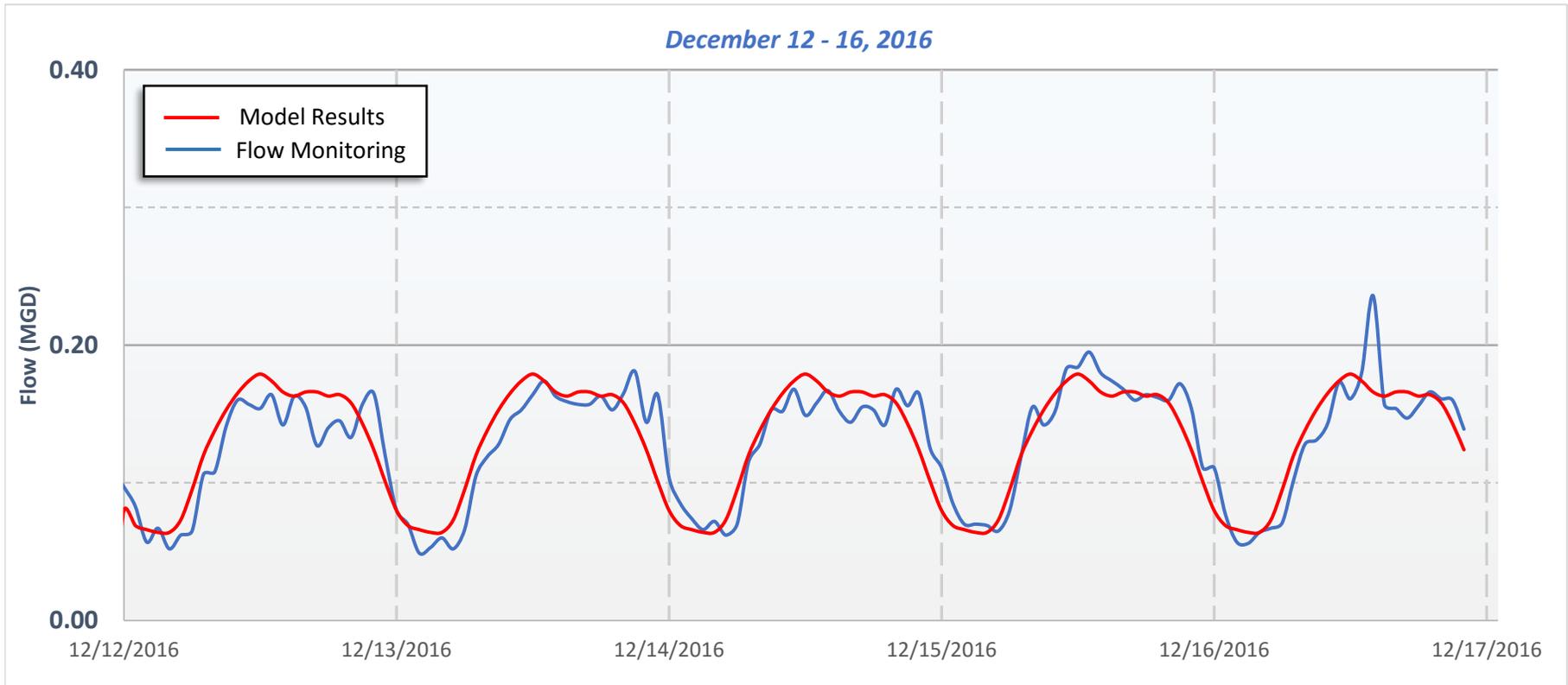
City of Tomball

Wastewater Master Plan

Dry Weather Calibration



Flow Monitor: S-05

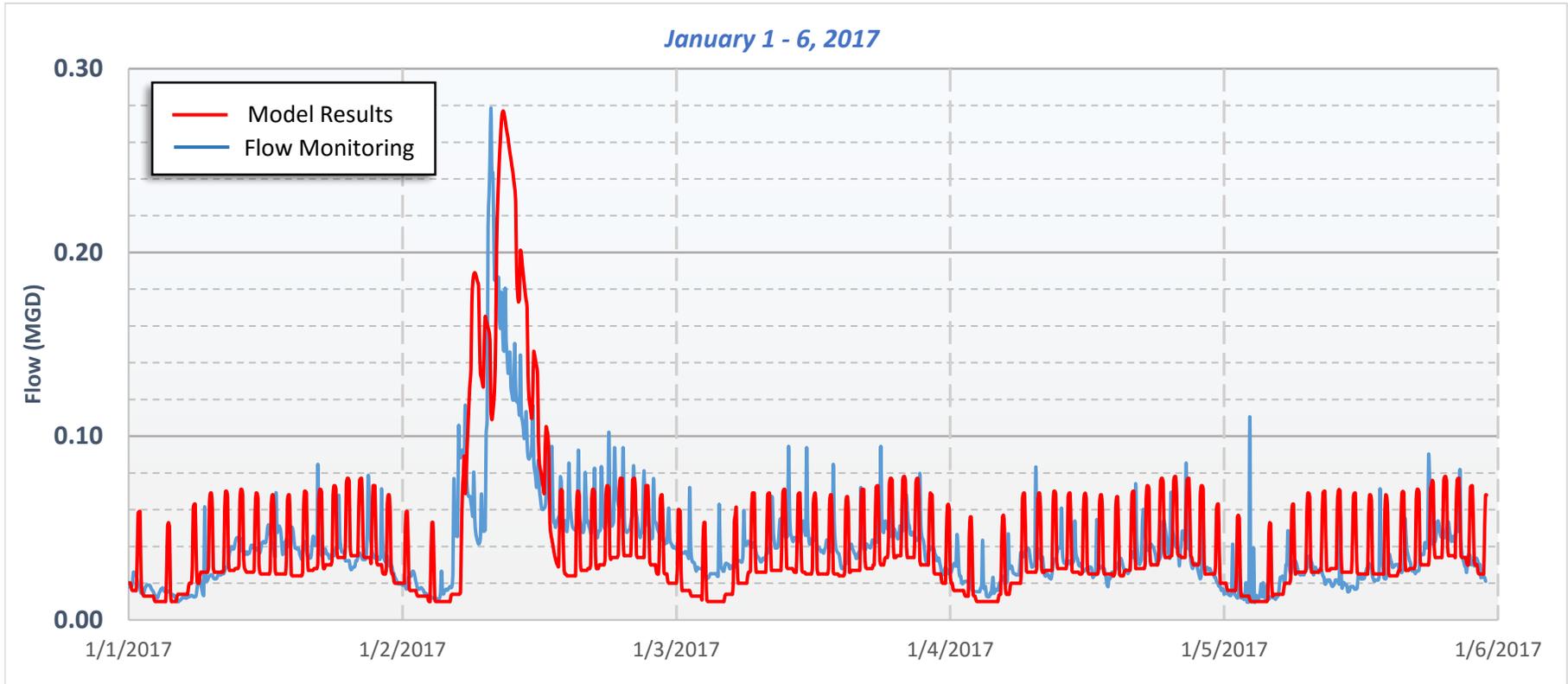


City of Tomball

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Flow Monitor: N-01

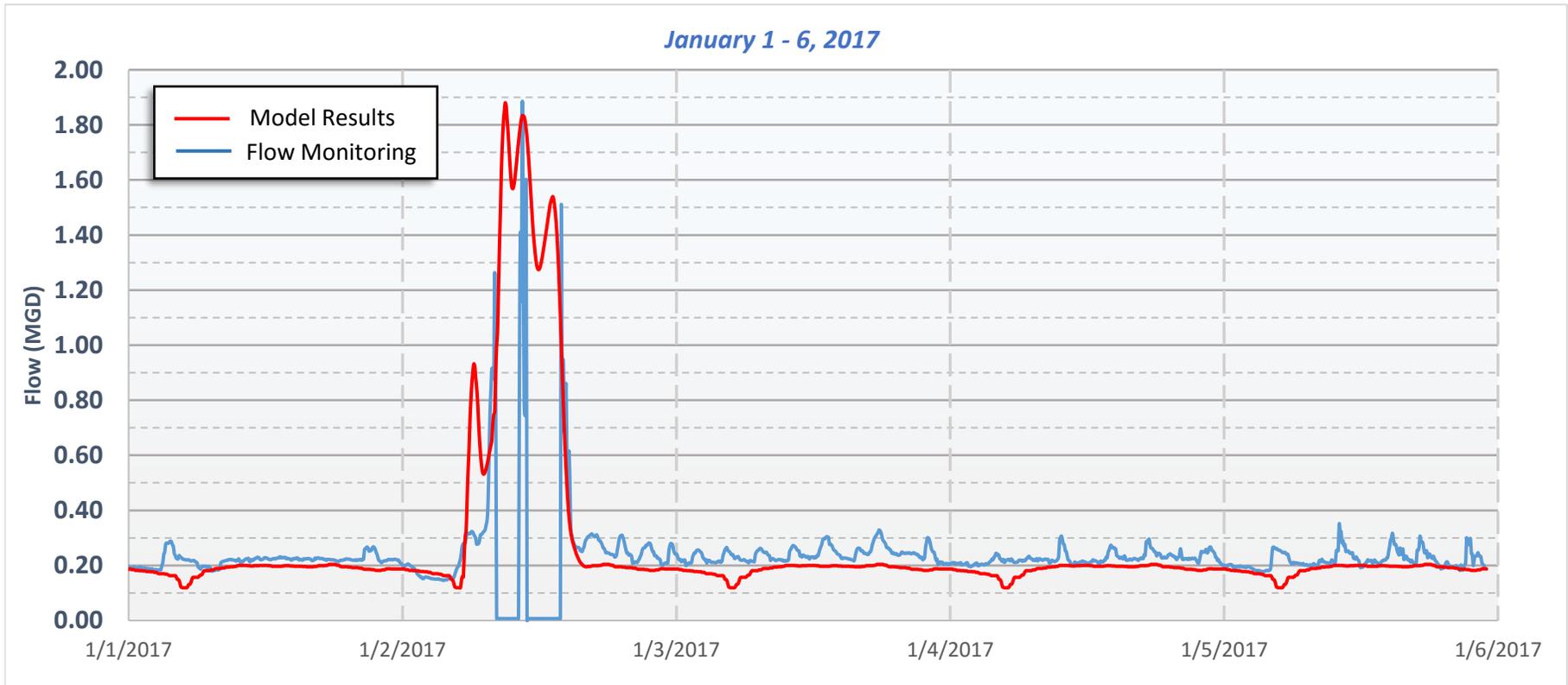


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Flow Monitor: N-02



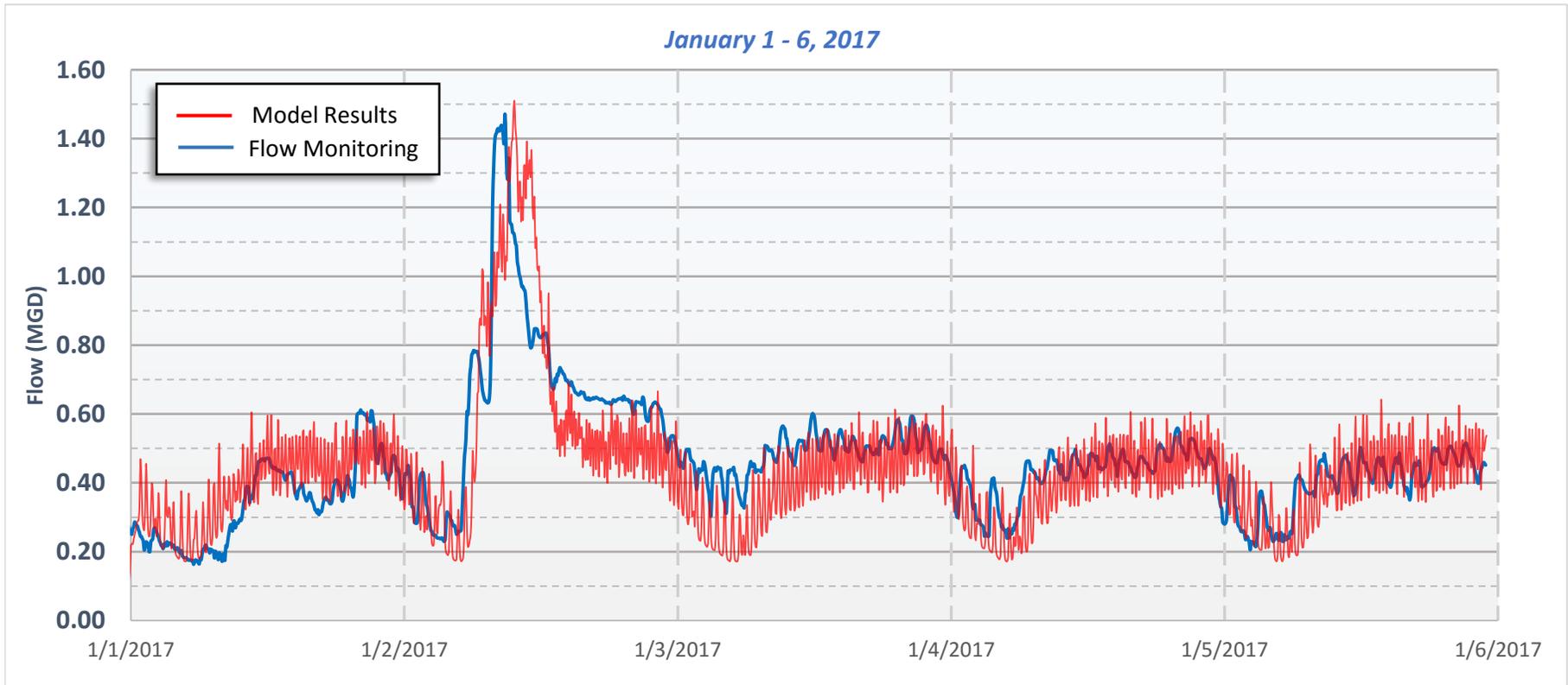
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Flow Monitor: N-03

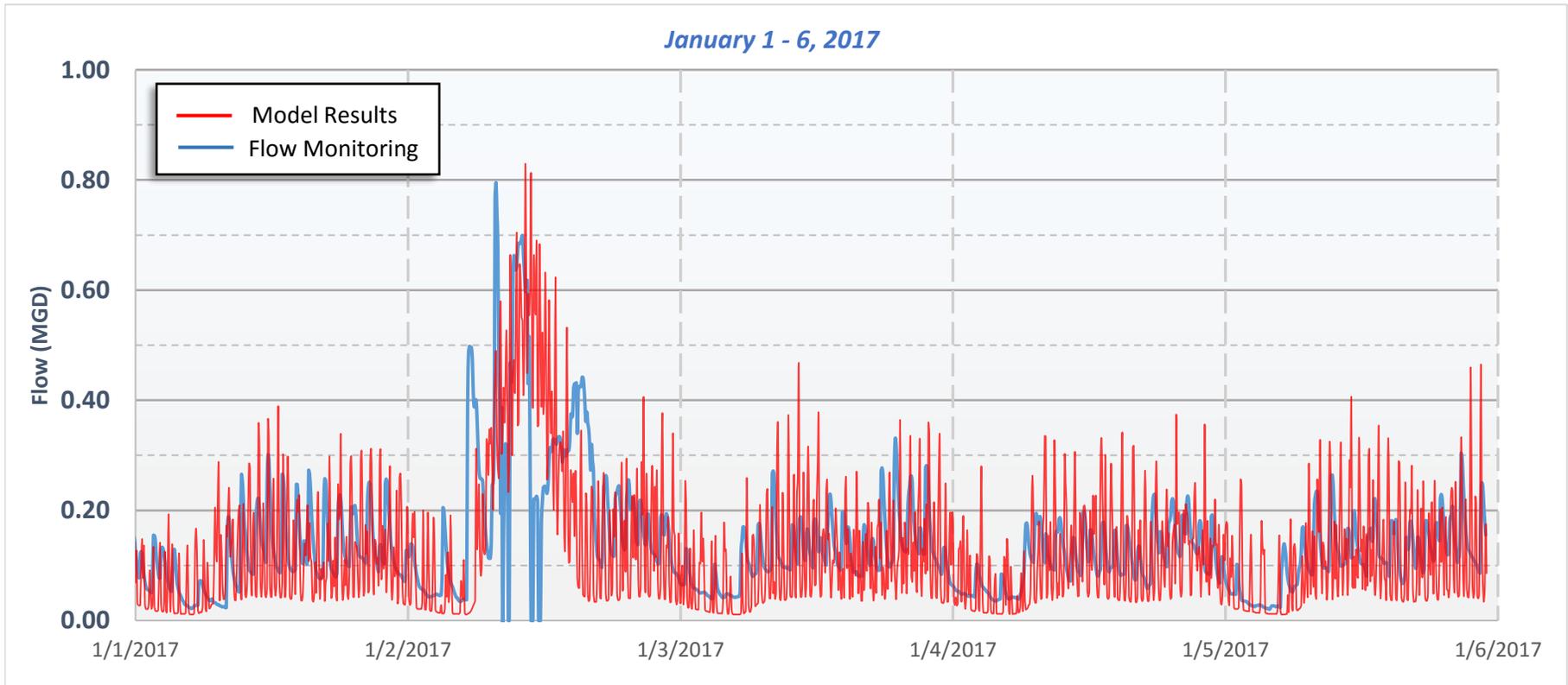


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Flow Monitor: N-04

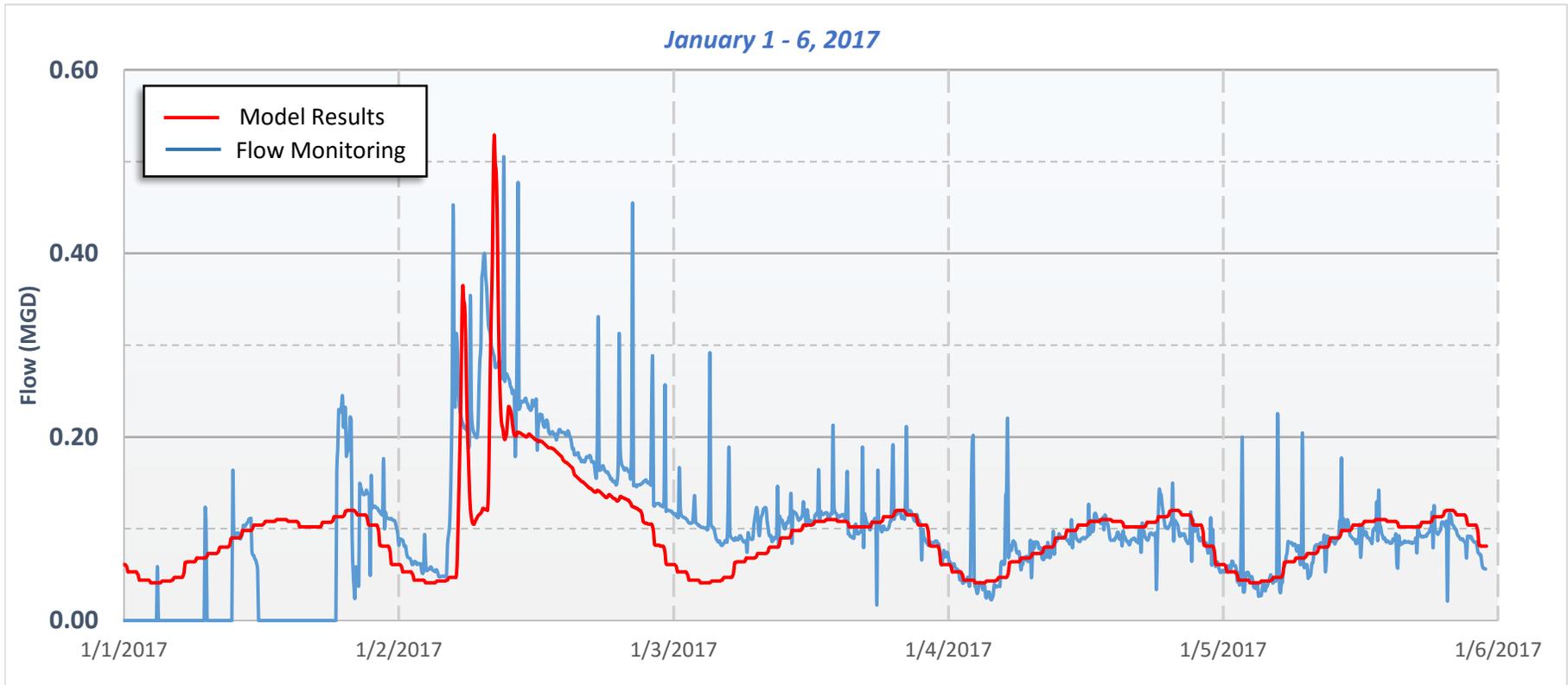


City of Tomball

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Flow Monitor: N-05



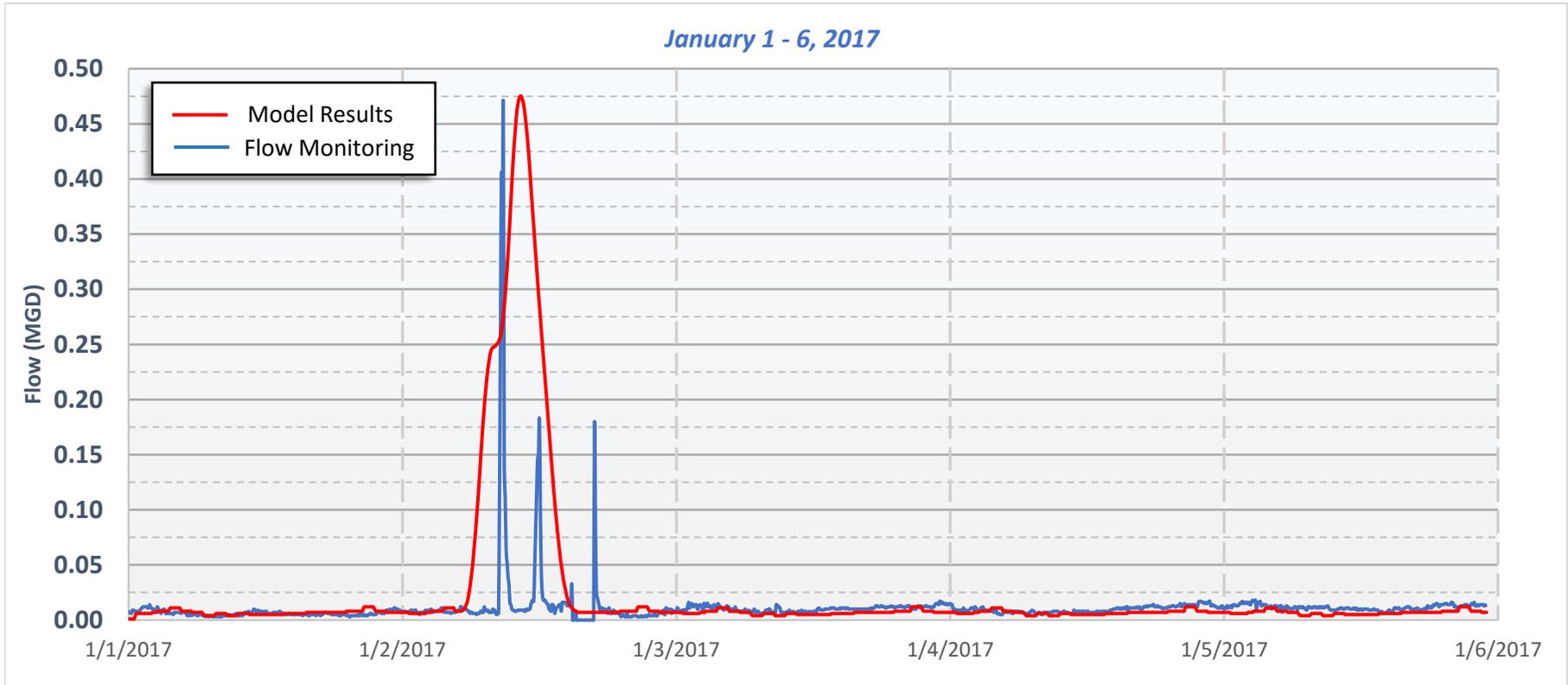
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Wastewater Master Plan

Wet Weather Calibration



Flow Monitor: S-01



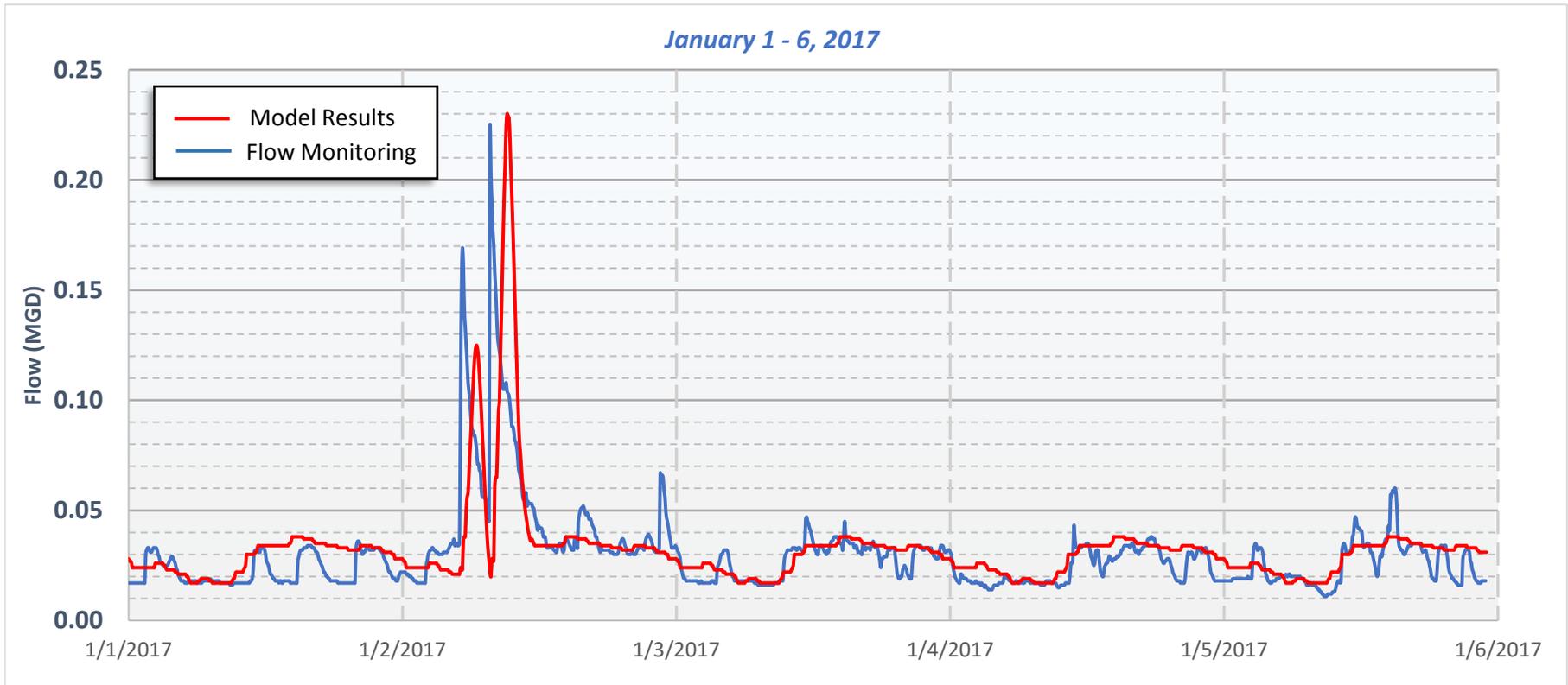
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Wastewater Master Plan

Wet Weather Calibration



Flow Monitor: S-02



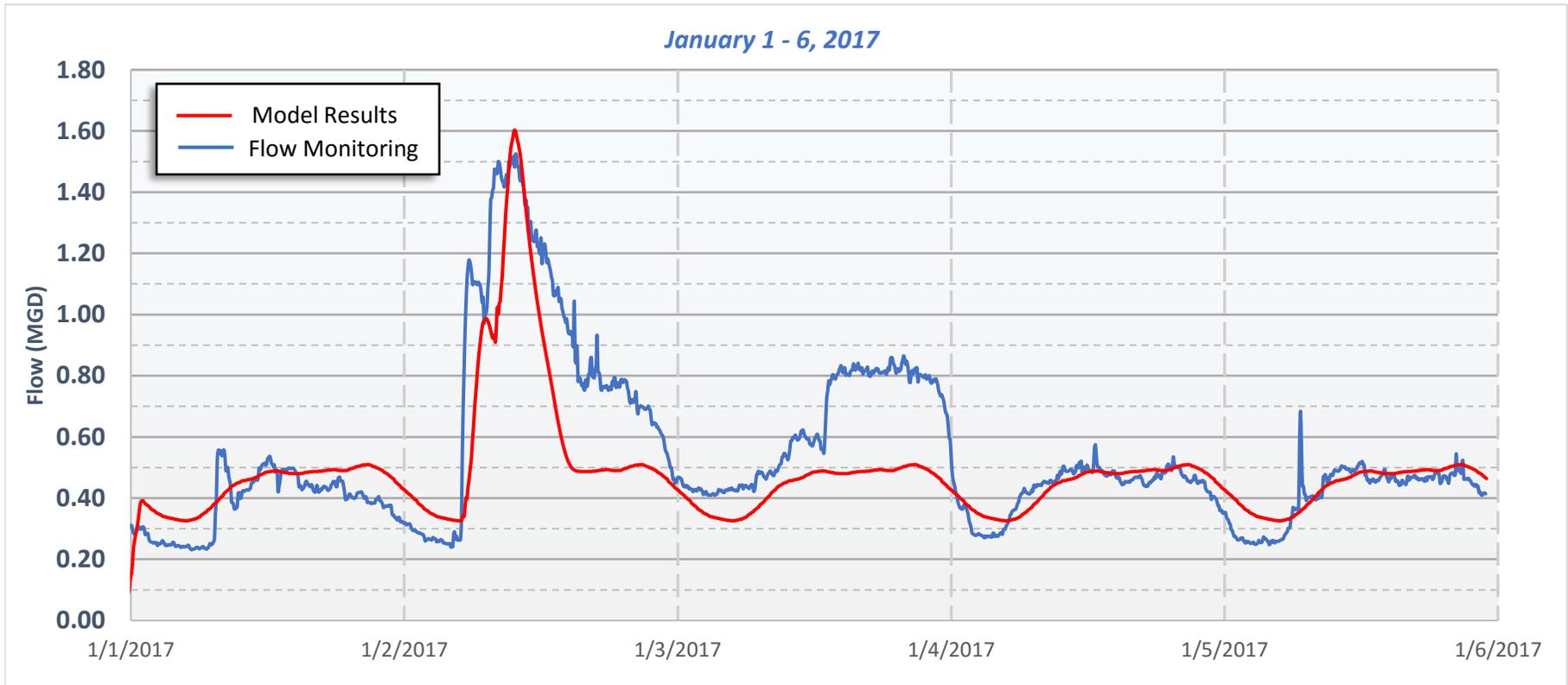
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Flow Monitor: S-03



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Flow Monitor: S-04



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Flow Monitor: S-05

